

SCIENTIFIC THEISM



ARVID REUTERDAHL

UCSB LIBRARY
X-79135

Digitized by the Internet Archive
in 2007 with funding from
Microsoft Corporation

SCIENTIFIC THEISM

Versus

MATERIALISM

SCIENTIFIC THEISM

VERSUS

MATERIALISM

THE SPACE-TIME POTENTIAL

BY

ARVID REUTERDAHL

DEAN OF THE DEPARTMENT OF ENGINEERING AND ARCHITECTURE,
THE COLLEGE OF ST. THOMAS



NEW YORK
THE DEVIN-ADAIR COMPANY
1920

Copyright, 1920, by
THE DEVIN-ADAIR COMPANY

All Rights Reserved by
THE DEVIN-ADAIR COMPANY

TO
MY WIFE
ELINOR LOUISE
THIS BOOK IS AFFECTIONATELY
DEDICATED IN RECOGNITION OF THE
UNTIRING INTEREST AND
ENCOURAGEMENT THAT
ACCOMPANIED ITS
DEVELOPMENT

PREFACE

HERMANN LOTZE, one of the most profound philosophers of recent and of all times, beginning with the idea of interaction, develops, in his work, a system of philosophy termed "Spiritualistic Monism" by Dr. Harald Höffding. The author accepts only the initiatory portion of the Lotzian concept of interaction, and develops it from the standpoint of physical science to its ultimate negatory conclusion in his Theory of Interdependence. A total negation of action, change, and becoming is the final result of this System of Complete Relativity. The actual facts of cosmic activity and becoming necessitate the dissolution of this negation by a Transcendent and Immanent Activity Principle. All the cosmic elements are activity elements. This is true of energons, vitons, and souls, but actual interdependent interaction of these elements is possible only through the abiding Eternal Life of the Absolute Principle. This is, in brief, what the author has named "Scientific Theism."

The author extends his sincere appreciation to Dr. E. Lee Heidenreich, the eminent consulting engineer, mathematician, and philosopher of Kansas City, Missouri, for his keen and encouraging interest in this work.

In the year 1896, the writer conceived his Theory of Interdependence as a System of Complete Cosmic Relativity requiring an Absolute Principle for the resolution of its paradoxical negations. In the same year he formulated the fundamental theses upon which this work rests. Basic amongst these theses was the conception that the laws of the primordial activity ultimates or particles are also the laws of the entire physical universe. Consequently we should be able to pass uninterruptedly from the activities of the sub-atomic particles to the behavior of such great material aggregates as planets. As an auxiliary or complementary thesis the writer held that the physical universe is composed of matter, and not of a combination of matter and ether. Therefore the writer regarded the ether medium

as a mathematical myth. Because of his Theory of Inter-dependence and his views that Space and Time are Forms of Apprehension, the thesis of Action At A Distance followed as a logical consequent. The first published statement of these views appeared April 5, 1902, in the Transactions of the American Electrochemical Society under the caption "The Atom of Electrochemistry." The greater portion of the mathematical analysis was completed in the year 1904, except that portion which refers to the development of the Keplerian laws, which was completed in September, 1914. In the year 1915 the author gave his lecture entitled "The Space-Time Potential" at the Kansas State Agricultural College and at the University of Kansas.

This work will not have proved in vain if it in some measure helps to inaugurate an era in which science, philosophy, and religion will constitute the invincible unitary triune guiding the soul in its search for Absolute Truth and Perfection.

ARVID REUTERDAHL.

September, 1920.

CONTENTS

SYNOPSIS.....	Page	9
CHAPTER	PAGE	
I	INTRODUCTORY SUMMARY	15
II	SOME INCONSISTENT CONCEPTS OF MODERN SCIENCE	45
III	ACTION AT A DISTANCE AND THE ETHER HYPOTHESIS	57
IV	THE PROBLEM OF A PHYSICAL SUB- STRATUM	92
V	THE MODEL OF THE PHYSICAL UNI- VERSE ACCORDING TO THE SPACE- TIME POTENTIAL	121
VI	NON-NEWTONIAN DYNAMICS. THE TRUE RELATION BETWEEN STATICS AND DYNAMICS	145
VII	SOME APPLICATIONS OF THE SPACE- TIME POTENTIAL	160
VIII	ELECTROLYTIC IONIZATION AND CELL ACTION	182
IX	THE FOUR WORLDS	191

APPENDIX A	A NON-NEWTONIAN DEVELOPMENT OF THE PLANETARY ORBITS	207
APPENDIX B	ELECTRICAL RELATIONS ACCORDING TO THE DYNAMICS OF THE SPACE-TIME POTENTIAL	228
APPENDIX C	CALCULATIONS INVOLVING HYPERBOLIC LOGARITHMS	253
APPENDIX D	THE SECONDARY FUNCTION OF THE SPACE-TIME POTENTIAL, AND THE ELECTRICAL CHARGE	257
APPENDIX E	ELECTROLYTIC IONIZATION. THE KAUFMANN EFFECT. THE RELA- TION OF WORK LOCI TO THE ATOMIC STRUCTURE AND DIAMETER. AVO- GADRO'S CONSTANT. THE SPACE- TIME POTENTIAL THEORY OF LIGHT SUBSTANTIATED BY RECENT ASTRO- NOMICAL OBSERVATIONS	264
APPENDIX F	INTERDEPENDENT AND INDEPENDENT MOTION. THE INTERACTION COEFFI- CIENTS. SOME BASIC FALLACIES OF PARTIAL RELATIVITY	273

SYNOPSIS

1. This work is a unification of science, philosophy, and religion. The fundamental truths of religion are derived philosophically from the facts of science.
2. The "Theory of Interdependence" (first conceived in the year 1896, and enunciated in the year 1902) is universal and complete, whereas the so-called "Theory of Relativity" is particular and partial.
3. Interdependence is the universal relativity of all action. It is complete mutual interaction in the entire cosmos. The "Theory of Relativity" follows from the geometrical relations pertaining to the sides of a right triangle in conjunction with the time form. These relations are then imposed upon physical phenomena. The "Theory of Interdependence" begins with the facts of physical action and concludes that every scientific statement concerning physical activity is merely a relative statement which contains no absolute explanation.
4. The Theory of Interdependence of the Space-Time Potential regards space and time as relative measuring standards of possible (potential) and actual (kinetic) motion and action. From the standpoint of the physical universe numbers are mere ratios and have only interdependent or relative significance. Physical values are composites consisting of numbers together with arbitrarily chosen physical units of well defined interdependent or relative dimensions. According to the Space-Time Potential all physical magnitudes and values are interdependent and interrelated. Paradoxical as it may seem, this fact of complete interdependence of physical magnitudes is the basic and sufficient reason for their complete *independence* of the actual physical dimensions arbitrarily adopted for the units of measurement. The second and complementary paradox to the above, and depending upon it, is that all physical values are constants or series of constants. If physical values were variable, we should have chaos instead of cos-

mos. A so-called *physical variable* is merely a *series of physical constants*, in which each constant in the series depends for its value upon the governing conditions existing at the place and time of observation. Consequently physical values are invariable magnitudes because they are ratios which are independent of the actual dimensions of the chosen physical units of measurement. Therefore a physical value is a *fact* and not a mere mathematical speculation. The third paradox is that, although physical values are constants, nevertheless, taken *in toto* for the entire cosmos, they are interdependent because of the fact that they are defined *ad infinitum* in terms of each other. This constitutes a complete and universal interdependence and relativity which forces us beyond the interdependent unitary system called the cosmos if we wish to find the actuating principle which is capable of transforming an otherwise dead and inert system into an operative and intelligible cosmos.

5. The constant values which pertain to the interdependent physical magnitudes located within an area equal to one ten-thousand-millionth of an inch exemplify the Laws of the Space-Time Potential with the same invariable rigor as obtains in the case of interdependent physical magnitudes found within an area equal to ten thousand million square miles. This constitutes the complete relativity of physical action (kinetic or potential) to space and time.

6. This work proves conclusively that the ether medium is a mathematical myth. These conclusions were verified experimentally by the astronomical observations of May, 1919, which showed that light rays behave like material particles, being deflected by the sun's interaction when passing relatively close to its surface.

7. The fundamental Newtonian concept of universal gravitation is regarded, in this work, as a particular case of universal interaction in an interdependent system. Newton derived the Keplerian Laws by a complete abandonment of his own concept of universality. In this work the Newtonian form of the gravitational expression has been abandoned, supplanting it with its anti-differential in conformity with the readily verifiable facts of the dynamics of bodies and sub-atomic particles. In other words, universal inter-

action is mathematically describable in terms of the inverse first power of the distance, whereas the norm of the Newtonian law of gravitation is the inverse second power of the distance. In this connection it is noteworthy that the mass of a sub-atomic particle is inversely proportional to its radial distance. By means of this important modification we accomplish the complete unification of the heretofore sharply differentiated worlds of physical atoms and bodies. This unification avoids the necessity of one set of laws for the behavior of atoms and sub-atoms and another set of laws pertaining to the activities of molecules, bodies, and planets.

8. Interdependent interaction involves action and reaction in conformity with the relative potential which pertains to the involved work loci.

9. Interdependent interaction involves action at a distance between all primordial material particles and their aggregates.

10. An action center or kern is a mass-acceleration kern. Mass regarded as an independent entity does not exist. Matter is composed of activity kerns, or centers, undergoing change in accordance with the laws of interdependence and interaction. Mass independent and separated from acceleration is not a physical reality. Acceleration apart from an action kern is merely a mathematical concept void of physical reality.

11. The principle of interdependent interaction involves the existence of primary and secondary matter. Physical phenomena consist in the interaction of primary and secondary matter and their aggregates. Every physical action involves an excitant and a concurrent material system. The monon is the primordial activity center. The energon is a neutral gyratory group composed of monons. The neutral energon is capable of change in a twofold manner, through infinitesimally minute gradations, to a high phase becoming an electron, and to a low phase becoming a positon. Primary matter is matter in the neutral phase. Secondary matter is matter appearing as electrons and positons. Gravitation is one form of interaction between molecular aggregates composed of groups of these ultimates.

12. In the organic world the primordial ultimate is the

viton. The principle of life is manifested in the viton. The viton is an elementary soul, lacking that potentiality which insures development into the highest form of conscious life. An organic center is the result of interaction between the primary activity of the viton and the secondary activity of secondary matter. God's ever present immanence insures to every organism an elementary soul or viton which is in harmony with its being.

13. The unitary conscious center arises through the conjunction and interaction of a primary and a secondary activity. The primary activity is the soul, which is capable of manifesting the principle of free individuality. The secondary activity is composed of highly developed organic systems capable of minute shades of responsive interaction. The soul is of God through an act of creation.

14. Number alone is incapable of accounting for the great diversity of existence types in the cosmos. The material primordials are endowed by a creative act of God with deterministic character. The so-called laws of nature are records of the characteristic behavior of these primordials.

15. The phenomenon of light is a case of interaction between an excitant and a concurrent material system. The velocity of light is a constant equal to the ratio of the velocities of the two systems. The truth of the former contention has been proved by the recent astronomical observations mentioned above. The latter deduction is in complete conformity with the Michelson experiment.

16. The variation in the magnitude of an activity kern with the variation of its velocity follows as a direct consequence of the work law of the Space-Time Potential.

17. The atom of the Space-Time Potential is composed of concentric work loci containing sub-atomic particles existing in phases ranging from the maximum radial (the electron) to the minimum radial (the positon) as we pass from the outside toward the center of the atom. This atomic model provides the necessary constituent variants to account for the spectrum.

18. Reality may be distinguished as absolute and relative. These two forms of reality are not identical but interrelated. Our theory of interdependence regards God as the

Absolute Reality, upon whom the relative reality of the cosmos depends for its maintenance and continuous existence. The cosmos, regarded from the physical standpoint only, is a relativity system devoid of an Absolute Principle. As such the physical universe is inert and inoperative. This is the ultimate philosophy of despair and pessimism. The relativity of interdependence finds its resolution and completion in the Absolute Principal of Activity, God. This is the philosophy of assurance and optimism. The theory of physical interdependence results in an inert and inactive cosmos unless this unitary inert system is related to the Absolute Activity Principle, known to religion as God. Such a system of *physical* relativity ends with an ultimate negation of all physical action. The actual facts of physical action force the resolution of incompleteness into completeness through the Life Activity of God. The complete theory of interdependence therefore includes the Absolute (God) as the physically, philosophically, and religiously necessary complement to the otherwise unintelligible and inoperative relativity system of the cosmos. Therefore physical interdependence becomes the greatest proof of the existence of God, in whom the riddle of relativity finds its answer and resolution.

CHAPTER I

INTRODUCTORY SUMMARY

1. God and the Mechanical Model.

Can science arrive at a consistent operative mechanical model of the universe without including the concept of God? We answer this question with an emphatic No! Can a consistent operative model of the universe be derived by the introduction of the concept of God? This question we answer with an equally emphatic Yes! The writer presents his discussion of these questions in the following chapters. The present chapter constitutes a synopsis of our position freed from its mathematical developments.

2. Pure Mechanism Futile.

When science, philosophy, and religion are placed together in the melting-pot of reason the result is the refutation of materialism. The scientific materialist denies the validity of the result for the reason that, for him, two of the ingredients in the melting-pot are worthless; philosophy is mere fantastic speculation, and religion is naught but an emotional phenomenon having its root in superstition. Materialists ignore the fact that every branch of science has its empirical and its speculative components; the empirical dealing with experimental facts, and the speculative dealing with the mathematical interpretation of these facts in terms of such scientific concepts as molecules, atoms, electrons, force and energy. We propose to show that speculative science, dealing as it does mathematically in concepts and "convenience unknowns," fails utterly in its attempt to construct a real world because of its refusal to admit the philosophical and religious interpretations of the world as a valid contribution to knowledge. In the following it will be shown that the concepts of science are unintelligible, inconsistent, and ineffective without the fundamental and

basic assumption of the existence of a rational, teleological, and purposive activity principle which unifies and vitalizes all reality into an ordered intelligible cosmos. Without the concept of God the conscious and the unconscious world become unintelligible. A mechanistic theory of the universe based upon mere materialistic concepts is rationally impossible. A mechanistic theory of the cosmos, grounded in the concept of God, and including teleology and purpose, is not alone rationally possible, but is the only theory which is consistent with fact. Such a mechanistic theory of the world is in agreement with empirical science, conforms with the results of philosophical reflection, and satisfies the demands of the religious consciousness. In other words, such a mechanistic world is an ordered spiritual cosmos, and not an irrational materialistic chaos. The physical universe becomes intelligible as a sublime and divine machine of wondrous potentiality, complexity, and diversity, vitalized by an eternal rational purpose. The phenomenal world is a manifestation of God in a Space-Time Potential.

3. Basic Principles.

The two principal tasks confronting us are: first, to show that the concepts of materialistic science are invalid and inconsistent because of their failure to include a rational, selective and purposive activity principle as their basic common element; and, second, to present a physical model of the universe which owes its ultimate significance and operativeness to that Eternal Being known to the religious consciousness as God. A candid and unbiased analysis of the data of empirical science, taken in conjunction with its speculative, hypothetical and interpretative substructure, forces us to accept the validity of the following basic principles:

1. The immanence of Divine Intelligence throughout the universe.
2. The cosmos as a unitary, interacting, rational, purposive and teleological system.

It follows that the physical universe is a finite projection of the Infinite in Space and Time, not independent of, but totally dependent upon, the immanence of God. The cosmos is a part of the infinite potentiality of God made actual in

a finite manifestation in space and time and in accordance with causation. The Space-Time Potential is that dynamic chart in which the eternal potentiality of the Spirit of God phenomenally manifests itself. It also follows that the physical universe, being a rational system, may be interpreted mathematically as a system exhibiting law and uniformity. A mechanistic model for this system may be conceived. The model is inoperative unless the validity of the first principle be assumed, and it is totally inadequate without the admission of the truth of the second principle. Moreover, physico-chemical forces are mere mathematical expressions devoid of a genuine activity principle unless both of the above premises are admitted as true. Consequently the reduction of vital phenomena to the physico-chemical forces of materialistic science is equivalent to the negation of becoming and change. Furthermore, becoming and change are inexplicable under any assumption which denies the validity of the two before-mentioned principles. The Space-Time Potential constitutes a direct challenge to materialism.

In this introductory synopsis we shall briefly discuss the fundamental hypothesis of science in order to prove the correctness of the contentions already enunciated.

4. The Unknowns of Science.

The Fundamental Concepts of Materialistic Science

In order to build a harmonious logical structure, modern science finds it necessary to invent terms expressive of certain phases of physical phenomena. Consequently we find in treatises upon particular branches of science, such terms as "the charge carried by an ion or electron, tubes of force, electrical field, ether, force, energy, matter, central force, attraction, repulsion, pressure, temperature, acceleration, velocity, momentum, mass, density, etc., etc." These terms of science may be broadly divided into two classes: those which pertain to phenomenal phases which are directly observed by the senses; and those which refer to phases which are inferred to exist either as physical antecedents or causal factors in the network of phenomena.

An inferential concept created by science for the purpose of rationalizing the observed facts of phenomena is of

the nature of an unknown physico-mathematical *X*. The scientist may assume one of two attitudes toward these physico-mathematical unknowns in his phenomenal equation; first, he may maintain that such unknowns are merely necessary conveniences introduced in order to complete the phenomenal equation without claiming actual reality for them; second, he may claim genuine reality for these thought creations in order to vitalize and actualize the observed phenomenal experience. If the scientist takes the second position he becomes a philosopher and a metaphysician. He may deny this assertion, but it is nevertheless true. Generally the scientist who aligns himself with the second attitude is a total failure as a philosopher and metaphysician, either because he is not in sympathy with the philosophical attitude, or because his lack of philosophical training prohibits him from developing a consistent, rational system. In either case such a scientist is profuse in his denunciations of that which savors of metaphysics, even if he himself is responsible for the unscientific creation. In order to avoid the pitfalls of the second attitude a great number of scientists seek refuge in the first position. This class of scientists create unknowns with impunity because they do not feel the restraint of responsibility for their creations. Making no claims for the reality of their concepts, they feel no liability in regard to the content injected into them. Physico-mathematical conveniences are regarded, by this scientific school, as having a right to exist on the principle that the end is justified by the means. In so far as such instruments of convenience deal with the genuine realities of a physical world they have no independent, unquestionable birthright, consequently we may justly demand that they be consistently defined and definitely related to that world order whose explanation is their only reason for existing. It is held that science finds its only legitimate and consistent field in the recording and correlation of experimental facts. The recording and correlating of these facts finally takes the form of some mathematical expression involving both types of factors, the observed and the inferred. This is particularly unfortunate for those who desire to avoid defining, interpreting, and relating the inferred factors to a

real world. This class of scientists attempt to avoid accountability for such "convenience unknowns" by saying that they care not what they are, but what they do.

5. Scientific Concepts Defined.

In order to examine the significance and implications of the concepts of modern materialistic science we shall briefly define them.

1. Mass is the Quantity of Matter.

2. Velocity is distance traversed in a Unit of Time.
Involves both Space and Time.

3. Acceleration is the increase or decrease in Velocity.
Involves both Space and Time.

4. Force is, or is measured by, Mass multiplied by Acceleration. Involves Space, Time, and Mass.

5. Kinetic Reaction is, or is measured by, Mass multiplied by Acceleration. Involves Space, Time, and Mass.

6. Impulse is, or is measured by, Force multiplied by Time. Involves Space, Time, and Mass.

7. Work is, or is measured by, Force multiplied by Distance. Involves Space, Time, and Mass.

8. Energy is, or is measured by, the Capacity for doing Work, or it is the Stored Capacity to overcome Force through Distance. Involves Space, Time and Mass.

9. Ether is Matter to Zero, or Infinite Limits including the ordinary Force functions correlated with Matter. It is Super-Matter and Force. Involves Space, Time, and Mass.

In order to define "Quantity of Matter" the materialistic scientist introduces the term Mass. When he is called upon to define "Mass," he states that:

Mass is, or is measured by, Force divided by Acceleration; or Mass is, or is measured by, Kinetic Reaction divided by Acceleration.

In the fourth item he has defined Force as being Mass multiplied by Acceleration, and in the fifth item he has defined Kinetic Reaction as being Mass multiplied by Acceleration. Consequently, "Quantity of Matter" has been defined in terms of Force and Acceleration, or Kinetic Reaction and Acceleration. Now since Force and Kinetic Reaction have been defined in terms of "Quantity of Matter," Mass, and Acceleration, it follows that the circle here com-

plete itself, and therefore it is clearly evident that the materialistic scientist has defined neither "Quantity of Matter" (Mass) nor Force and Kinetic Reaction.

6. The Closed Chain of Concepts.

It follows from the above definitions that the materialistic scientist has failed to define the concepts, Impulse, Work, and Energy, for the reason that he has not given us a satisfactory definition of Force. Hence Impulse, Work, and Energy are included in the closed circle of his speculations. Of the nine items considered there remain the terms Velocity, Acceleration, and Ether. The last term will be disposed of later in our discussion. Both Velocity and Acceleration involve the notions of Space and Time. In fact, all the concepts owe whatever significance they may possess to the meaning of Space, Time, and Mass. We have seen that Mass is in the *closed chain* including Force, Kinetic Reaction, and Acceleration.

7. The Empirical Position of Science.

Is it pertinent for us to ask the materialistic scientist to define Space and Time? By his own definitions he has been driven back to the notions of Space and Time as fundamentals. His own definitions have defined nothing because he has been caught in a circle which he has not been able to cut. He has forged a closed chain of interdependent conceptual links without being able to enlighten us in regard to the independent significance and meaning of a single link. In regard to the notions of Space and Time the physicist may reply that the yardstick and the chronometer satisfactorily represent space and time for him. He is not interested in any metaphysical speculations concerning the ultimate nature of space and time. In that case the physicist becomes an empiricist who deals only with experimental data. As an empiricist he will be well within his rights if he formulates working hypotheses to assist him in the further pursuit of physical data.

8. Faith in the Rationality of the World.

If he claims any further significance for his working hypotheses, then he must show that they are in complete agreement with the fullest significance of reality. An

attempt to do this will take him beyond the bounds of empirical science, forcing him into the field of "metaphysical speculation." We have the right to demand that his working hypotheses be consistent and true to reality. Moreover, any hypothesis which purports to introduce a real activity principle into the universe must be defined, not by an argument in a circle, but by a distinct idea harmonious with the totality of the universe. If it is his desire to build a genuine dynamic world of becoming and change, then his concepts must partake of a basic concept capable of accounting for the real activity manifest in the cosmos. This basic concept must potentially include all the observed functions in the physical world. This fundamental concept must include reason, purpose, and teleology. Without purpose and teleology, the world becomes irrational. Ultimately our thoughts and actions rest upon faith in the persistence of a rational world order. Moreover, every inference and deduction arrived at through the process of thought is based upon the fundamental premise that the world is rational. This premise cannot be derived through the method of logic. Lack of faith in this as the fundamentally given makes knowledge impossible and transforms cosmos into chaos through an absolute skepticism. Such a skepticism is self-destructive because it is based upon the self-annihilatory assertion that the only truth in the world is that there is no truth.

9. The Activity Principle.

The mechanistic models evolved by the materialistic scientists are based upon the concepts enumerated above. Since they constitute a closed chain, their actuating dynamic principle must be found either within or without the closed chain. It should be evident that no genuine and real activity principle is found within this closed chain. Neither Force nor Energy can constitute this activity principle, because the former is defined in terms of Mass and Acceleration and the latter is measured in terms of Force and Distance.

This activity principle cannot be defined in terms of Mass, because Mass is defined in terms of Force and Acceleration. Underlying the notion of Acceleration we find the basic notions of Space and Time. In view of the preceding,

the significance of the title "Space-Time Potential" should be apparent.

It may be affirmed that in the synthesis of the concepts of either Mass and Force, or Mass and Energy, the sought activity principle may be found. The mere putting together of two concepts, neither of which contains a third necessary concept, is a totally ineffective procedure. Nothing can come out of this mere synthesis other than that which is previously contained in the constituents. Furthermore, if the three concepts, Mass, Force, and Energy, are to be given genuine independent significance, at least one of the concepts must be independently defined. As defined by science they are interdependent and relative, and as such have naught but relative significance. Speculatively, however, science thinks of Mass and Force as separate and distinct entities totally different in their ultimate nature. This is another glaring inconsistency in the annals of materialistic science. The convincing "forcefulness" of the word Force has a seductive effect upon the reasoning faculties. Through centuries of scientific repetition this word Force has bewitched the reason. It is the great *ignis fatuus* of science which lightens the dreary quagmires of materialism. Within the closed chain of scientific concepts we find nothing capable of generating an activity principle. In their totality these materialistic concepts cannot generate one single physical action. The unbiased thinker is forced to the conclusion that the closed chain is impotent and incapable of evolving a mechanistic model which can pulsate with genuine action. The inference is forced upon us that the actuating dynamic principle must be sought outside of the closed chain in the Life of God. The immanence of God in the world then follows as the only hypothesis which will account for cosmic activity.

10. The Gods of Science.

We have been taught to bow in reverence before the shrine of materialistic science and to worship its physico-mathematical gods, and we are expected by materialism to revere no other God, for there is no God other than those manufactured in the laboratories of materialistic science. Stripped of their technical adornment, these gods of science

prove to be nothing more than inert clay energized from time to time by hypodermic injections of powerful doses of the calculus. Science has accomplished wonders through experimental research, but when materialism tries to construct a consistent cosmos from materialistic concepts, then reason receives its greatest insult. The materialistic scientist is a total failure when he tries to enter fields beyond the confines of his laboratories. We are tempted to make the sweeping assertion that most scientists are incapable of consistent thought when dealing with the problems of reality. We have exposed the weakness in the very foundation of materialism. Even the least initiated layman in science must revolt at the thought of giving reverence to the impotent Closed Chain of Concepts manufactured in the laboratories of materialism. This closed chain of science has no peer in the archives of fallacy. The House of Materialism is built upon a conceptual substructure composed of the most blatant fallacies ever inflicted upon an unsuspecting public. The forging of the closed chain by the blacksmiths of materialism is the greatest crime ever committed against reason.

In the above we have shown that the fundamental concepts of materialistic science have no significance when applied to reality. They contain no real actuating principle as their common basic element. Consequently, the world built up by materialism is incapable of exhibiting phenomenal activity. We have admitted that empirical science has accomplished marvels, and has been a power in the uplift of mankind. We have conceded that for science the working hypothesis is indispensable. We have cautioned science not to claim too much for its working hypotheses. They must be consistent with facts. We demand that science cease its scoffing at religion and philosophy because of its total failure to deal consistently with problems outside of its own domain. We insist that religion and philosophy be restored to their rightful place in the domain of human affirmation and knowledge.

11. The Blunder of Materialism.

In the preceding discussion we have shown that the House of Materialism is built upon the quicksand of a Closed

Chain of Concepts. Not one conceptual link in the chain is independently defined. Taken *in toto* they contain no real activity principle capable of explaining the smallest fragment of physical action. This colossal blunder of materialism forces us to look with suspicion upon its claims to superhuman intellectual sagacity. The speculative substructure of materialistic science is devoid of common sense. It is not flattering to the intellectualism of the present century to be forced to admit that a large percentage of sincere thinkers have been completely hoodwinked by the impotent barrage of intricate mathematics sprayed over the battlefield of materialism's Armageddon.

Some Auxiliary Concepts of Materialistic Science

12. Lines of Force.

In this paragraph we shall put some of the much cherished auxiliary concepts of materialistic science to the test of common sense. We shall begin the investigation by a consideration of the Tube of Force developed by the eminent English physicist Sir J. J. Thomson, Professor of Experimental Physics in the University of Cambridge. A few citations from Thomson's "Electricity and Matter" will bring the notion before us. "If iron filings are scattered on a smooth surface near a magnet they arrange themselves in well-marked lines which can be traced from one pole of the magnet to the other; the direction of these lines at any point coincides with the direction of the magnetic forces, while the intensity of the force is indicated by the concentration of the lines. . . . I have spoken so far only of lines of magnetic force; the same considerations will apply to the electric field, and we may regard the electric field as full of lines of force, which start from positively and end on negatively electrified bodies. . . . To Faraday the lines of force were far more than mathematical abstractions—they were physical realities. Faraday materialized the lines of force and endowed them with physical properties so as to explain the phenomena of the electric field. Thus he supposed that they were in a state of tension, and that they repelled each other. Instead of an intangible action at a distance between two electrified bodies, Faraday regarded

the whole space between the bodies as full of stretched, mutually repellent springs. The charges of electricity were, in this view, just the ends of these springs. An electric charge was an extensive arsenal of springs spreading out in all directions to all parts of the field. . . . If through the boundary of any small closed curve in the electric field we draw lines of force, these lines will form a tubular surface, and if we follow the lines back to the positively electrified surface from which they start and forward on to the negatively electrified surface on which they end, we can prove that the positive charge enclosed by the tube at its origin is equal to the negative charge enclosed by it at its end.”¹

13. Tubes of Force.

Tubes constructed from lines of force constitute the Tubes of Force of Thomson. He gave the name “Faraday Tube” to a tube of force which enclosed a unit charge. He states that “motion of the Faraday tubes is accompanied by the production of magnetic force.”² In his “Notes on Recent Researches in Electricity and Magnetism,” Thomson states: “The result of the different effects on the energy of the atom produced by the incidence of a Faraday Tube will be the same as if the atoms of different substances attracted electricity with different degrees of intensity. . . . The Faraday tubes when they reach a conductor shrink to molecular dimensions.”³

The reader is here advised to draw a long breath for the sake of his health, and in recognition of the seeming profundity of the Thomsonian speculations. Let us examine the Thomsonian pretensions to profundity.

When iron filings “arrange themselves in well-marked lines” are these lines physical realities or are they merely lines along which physical realities arrange themselves? Faraday maintained that the lines of force were physical realities in order to avoid the Supreme Terror of Materialism, which is Action at a Distance. This bogey of material-

¹ Electricity and Matter, pp. 8, 9, 10, 14.

² *Ibid.*, p. 18.

³ Recent Researches in Electricity and Magnetism, p. 5.

ism has always haunted the scientist and driven him to invent mathematical sticks with which to bridge the vacuous abysses between material particles. The Thomsonian Tube and the Ether are mathematical sticks manufactured for the purpose of beating the bogey into insensibility. For the "simple-minded" believer in God this bogey has no terror. Mathematical sticks are mere worthless playthings venerated by materialism. In the following we shall show that with a proper understanding of the nature of Space and Time in their relation to the Finite and the Infinite, Action at a Distance need cause us no consternation. Faraday's claim of physical reality for the line of force involves Thomson in the same contention for his tube of force unless he repudiates the Faraday interpretation. Thomson speaks about "effect produced by the incidence of a Faraday Tube." He also refers to the "motion of the Faraday tubes." These statements would indicate that Thomson believes in the physical reality of his tubes. The incidence of a tube could produce no effect on anything unless it possessed physical reality. The tube may be a thought, a metaphysical concoction, a ghost, a mathematical essence or extract, an emotion, a superstition, or any thingless something, in which event the materialistic scientist would frown with horror at the notion that such a "nothing" could do something and produce effects. Thomson may reply that a tube of force is composed of lines of force and therefore the tube is very "forceful" and can accomplish almost everything.

14. Force is not an Entity.

What, then, of the line of force? Is it a mere line or is it force? If it is force, then we ask Thomson what he means by the effects produced by the incidence of force on the atom? Is force an entity distinct from matter? If so, then we must assume that force is of an immaterial nature. Materialistic science does not admit that the immaterial can produce effects upon the material. Materialism holds that all physical change is brought about by the action of one or more material groups upon another material group. Science defines force in terms of the product of mass and acceleration. If force is not immaterial and an entity independent of and distinct from matter, then this definition conveys no

more information than the fatuous statement that the amount of change in a matter group is proportional to the product of its mass by the resulting observed acceleration. In other words, if we compare the product of mass and acceleration in one matter group with a similar product for a second matter group and find the latter to be twice the former, then the inference is that the amount of the change sustained by the latter is twice that of the former. No sane person can regard this inference as indicating exceptional intellectual acumen. If this is the intent of the definition of force submitted to us by science, then we have merely been shown how to measure the amount of the change observed in a matter group. What is the reason, then, for the feverish desire of science repeatedly to flaunt the word "force" before our eyes? If the latter notion be the scientific intent of the word "force," then the term is superfluous. Mass and acceleration are sufficient for the purpose indicated. The word "force," however, has always contained a peculiar mystical charm for science, and it has been exceedingly useful in covering a multitude of sins. Unfortunately for science, the term "mass" has been defined in terms of force. Again we hear the monotonous rattle of the links of the closed chain. If science admits that force is a genuine immaterial entity manifesting itself in the physical universe, then the House of Materialism crumbles. Materialism has then dug its own grave. We have seen that the work of science hinges upon the validity of the statement that the world is rational. If this is not admitted, then the achievements of science are worthless. Given a rational world order and an immaterial force, and we are not far distant from the concept of God. Through its own concepts science is forced to the concept of God.

15. The Monon or Force Center.

We must not leave the remarkable tube hypotheses without a reference to the curious contention that the tubes are in a "state of tension, and that they repel each other." We can conceive of tension in a material body, in which case science accounts for this state as being due to the action of a force, whatever science may think that it means by force. If force is an irrational, immaterial entity, then sci-

ence must show us how force acts upon matter. If force is matter, then science faces the problem of explaining how matter acts upon matter. Science has not explained either possibility. If force is merely a mathematical term, then it is worthless as a principle of action. If force is a rational activity principle manifesting in the universe, then we discern the immanence of God in the physical world. A rational world order cannot have been produced by an irrational entity; hence whatever notion we hold concerning force, it cannot be irrational. No process of evolution can ever generate the rational from the irrational. Possibly Thomson wishes us to think of his tube of force as a self-mover, a thing of primitive and rudimentary life, in which event it would be able to produce effects upon things other than itself. If this be the Thomsonian notion, then the tube must be endowed with at least a fragmentary portion of selective intelligence, otherwise it could not behave in a consistent and uniform manner. If the principle of selective intelligence be conceded to the tube then the foundations of materialism fall and we are again brought face to face with the concept of God. The tube of force of Thomson, after due consideration, proves to be a very hollow concept. The concept has merely helped science to round out its complete fiasco of impotent hypotheses. According to the view of the Space-Time Potential, force and matter never were distinct entities. The definition given to us by science proves this contention. The dualistic position of materialism is a complete failure. We find the solution of the dilemma of materialism in the variable unity of force and matter in a genuine Monon or Force Center which owes its entire significance to the immanent rational activity of God in the physical universe.

16. The Failure of Conceptual Bridges.

The dualistic theory that force and matter are distinct entities involves science in an unending chain of difficulties. Force must find its way from one group of matter to another; it must make itself known from one material aggregate to another such aggregate. As a consequence of these difficulties there arose the much mooted question if forces can make themselves known at a distance without the

intervention of a transmitting vehicle or medium, or if force effects must have a medium through which they can travel from one group to another. Science has always abhorred the vacuum. For that reason it created the notion of a medium or ether to bridge the gulf between matter groups. We shall show that this attempt of science is a total failure. All the sticks and glue of materialism never will bridge the gap. The concept of God is the only concept which will bridge it. With this concept, Action at a Distance loses its terrors and the ether hypothesis becomes entirely unnecessary.

17. The Ether as a Materialistic Substitute for God.

In every instance where materialistic science has obstinately resisted the introduction of the concept of God into the physical universe it has been caught in a maelstrom of inconsistencies. This is true of the frantic attempt of materialism to substitute the concept of the ether for the concept of God. Materialism has always looked upon the introduction of the concept of God into the physical world as the unforgivable sin. The ether has been one of the main weapons used by materialism in its attempt to drive God out of the universe. If the world had not been completely etherized into unconsciousness by the results attained by empirical science, then the ether hypothesis would long ago have been regarded as mere speculation devoid of logical consistency. The physical content of the ether has been determined by the rigorous method of mathematics. Imagine, for a moment, the reliability of such a farcical procedure! No genuine physical proof of the existence of the ether has yet been produced by science. The ether is an inferential unknown sprinkled by science into the voids between matter particles. What ingredients have been used by science in the manufacture of the ether hypothesis? The calculus plus awe-inspiring differential equations mixed with as many inconsistencies as could be rammed and tamped into the confines of its most accommodating infinite lack of limiting boundaries. There are almost as many ethers as there are physicists. Certain resemblances to matter are evident in every ether hypothesis. The ether model is always based upon certain fundamental properties

of matter, reduced either to zero or raised to infinite limits. The continuous occupation of space is common to all of them. Matter is here and there. Ether is supposed to be everywhere. Hence we have, in the notion, the space occupation of matter raised to infinity. At the outset it was a protest against the emission theory of Newton. When it is thought of as a solid it is endowed with incompressibility.

Other theorists ascribe infinite compressibility to the ether. F. Neumann and MacCullagh adhered to the incompressibility notion, while Fresnel preferred the hypothesis of infinite compressibility. We are told by some physicists that the ether is structureless, incompressible, motionless, but capable of being set into motion, non-elastic, capable of indefinite subdivision, and that the resulting parts can move over each other without friction. No known physical reality in the universe satisfies these specifications. Empty space (vacuum) qualifies better than any form of matter. If the ether is not mere empty void, then the specifications are more closely satisfied by the supposition that the ether is real but immaterial. Certainly the ether cannot be material in its nature and satisfy the requirements imposed upon it by physical phenomena. After all is said, the ether is merely an imagined realization of the physical requirement that at every instant there shall everywhere be a reality which is in intimate responsive connection with matter. This reality cannot be material in its nature, for no form or type of matter will satisfy its requirements as outlined by science. The writer, in his Space-Time Potential has considered all the phases and implications of the ether hypothesis. In every form of the hypothesis one basic element is missing, without which the ether model becomes inoperative. This basic element is selective intelligence. It is not to be inferred that the addition of the element of selective intelligence will make the ether model operative; on the contrary, the hypothesis is so filled with inconsistencies that it is beyond redemption. The absence of the element of selective intelligence, taken in conjunction with the fact that the sought for reality must be immaterial, indicates that we are again face to face with the concept of God. Any possible future substitute for the ether

hypothesis will involve similar difficulties and inconsistencies unless the concept of God becomes the basic element of its hypothetical content. The concept of God solves the riddle of the physical universe. All the concepts of science cannot displace it as the keystone of the universe. The inadvertent groping of materialism for a substitute for the concept of God has opened the door of reality and brought to us the realization that its search is futile unless it admits the fundamental truth of religion.

18. The Contribution of Boscovich.

The problem of Action at a Distance has always been a bugaboo to the scientific world. Stated concisely, the question is, Can matter act where it is not? Must discrete portions of matter be connected by an intermediate something, a medium, plenum, or ether, by means of which one material system can be placed, as it were, *en rapport* with another distant material system? Daniel Bernoulli answered the former question in the affirmative and denied the necessity of a medium. Ruggiero Giuseppe Boscovich, the brilliant Jesuit mathematician, physicist, and astronomer, professor of mathematics at the Collegium Romanum, in a work entitled "Theoria Philosophia Naturalis," published at Vienna in 1758, maintained with Daniel Bernoulli that action at a distance is possible through an absolute vacuum. For him matter consisted merely of force centers endowed with inertia, and all physical and chemical activities were explainable as mutual attractions and repulsions varying in intensity with the magnitude of the intervening distance. The prophetic vision of Boscovich concerning the ultimate nature of matter has recently been verified by the researches of Kaufmann (1903), J. J. Thomson, Heaviside, and Searle. These famous physicists may be loath to admit that they have experimentally verified the contentions of Boscovich concerning the nature of matter. In fact, we suspect that they would reprimand us in no uncertain language if we insinuated that they have contributed one iota to the force-center theory. Dr. Rutherford, referring to the work of these men in his book entitled "Radio-Activity," says: "The above results are therefore in agreement with the view that the mass of the electron is altogether electrical in

origin and can be explained purely by electricity in motion.”¹ In his “Electricity and Matter,” J. J. Thomson states: “I have calculated from this expression the ratio of the masses of the rapidly moving particles given out by radium to the mass of the same particles when at rest, or moving slowly, on the assumption that the whole of the mass is due to the charge, and have compared these results with the values of the same ratio as determined by the Kaufmann experiments. These results support the view that the whole mass of these electrified particles arises from their charge.”²

19. The Divisibility of the Atom.

The eternally stable and unchanging atom of Dalton is gone forever. The atom is composed of sub-atomic parts. It is a veritable microcosm, a minute planetary system whose constituent parts are in continuous motion. It is composed of such smaller primordial parts as electrons or corpuscles whose mass is not fixed, but changes with a change in velocity. Science measures force in terms of the product of mass and acceleration. In the electronic particle we have a changing entity whose magnitude is measurable in terms of force. Therefore we assert that scientific research has brought us back to the force center of Father Boscovich.

20. Mass and the Ether.

Further on in the same work, Thomson continues: “All mass is mass of the ether, all momentum, momentum of the ether, and all kinetic energy, kinetic energy of the ether. This view, it should be said, requires the density of the ether to be immensely greater than that of any known substance.”³ It is evident that Thomson is no intentional supporter of the force center theory of Boscovich. Again the ether becomes the scapegoat for the farcical speculations of science. Thomson also states that “the whole mass of any body is just the mass of ether surrounding the body which is carried along by the Faraday tubes associated with the

¹ Radio-Activity, p. 112.

² Electricity and Matter, pp. 47, 48, 51.

³ *Ibid.*, p. 51.

atoms of the body."¹ In speaking of the constitution of the atoms, Thomson says: "Let us then take as our primordial system an electrical doublet, with a negative corpuscle (electron) at one end and an equal positive charge at the other, the two ends being connected by lines of electric force which we supposed to have a material existence."²

We are told by science that the mass (quantity of matter) of the electron (or corpuscle) is altogether electrical in origin. The whole mass is due to the electrical charge. Then we are informed that the whole mass of any body is just the mass of ether surrounding the body which is carried along in the moving van composed of Faraday tubes associated with the atoms of the body. Atoms are composed of negative corpuscles and positive charges hitched together with material ropes called lines of electric force. The mass of any body is not the mass of the body, but it is the mass of the ether which surrounds it. The mass of your body is the mass of the clothes which surround you. Atoms are composed of electrons. Electrons are electrical. Electricity is mass, and mass is ether, and the ether must be immensely denser than a materialist, or any other known substance, in order to behave properly. Lines of electric force are material. Matter is electrical. Thus the materialistic scientists disport themselves on their conceptual merry-go-round whilst the calliope of materialism shrieks its weird song, "Great is the Ether of the Materialist!" We have disposed of the ether as an absurd, fantastic inconsistency.

21. Physical Action Involves Action at a Distance.

Returning to the problem of Action at a Distance, we have shown in the Space-Time Potential that physical action is impossible unless we assume that action at a distance is possible. The assumption that contact in space is the indispensable preliminary condition for mutual action is of no avail because we must explain why and how spatial contact causes previously independent and alien things, states, or forces to become interested in each other, thus producing the phenomena of change. The fundamental error underlying all scientific hypotheses is the supposition that things

¹ Electricity and Matter, p. 51.

² *Ibid.*

are independent. If things are independent, then action at a distance becomes inconceivable. The gap between independent things must be bridged. Consequently science drags forth its conceptual sticks and glue in order to unite the independent things. If the things of the physical universe are independent, then all the conceptual sticks and glue of science cannot make them mutually dependent. Materialism has struggled to build a consistent model of the physical universe from independent things and scientific concepts. We have seen the House of Materialism crumble because of its inconsistent and impotent hypotheses. The failure of materialism is complete. We shall show in detail in the following chapters that physical action is impossible unless we admit the mutual dependence of all centers of reality in an interacting unitary system. In such a system action at a distance is easily comprehended and loses all its repulsiveness. This interacting unitary system is the finite projection of God in Space and Time. The eternal immanence of God maintains the system.

22. Summary of the Criticism.

In the preceding critical review of the position of science we have shown:

1. That such scientific concepts as mass, force, energy, and work are conceptual links in a closed chain, out of which science cannot extricate itself. Within this closed chain there is no genuine activity principle capable of generating physical action. The actuating principle must therefore be found, outside of the closed chain, in the Life of God.

2. That such auxiliary concepts of science as tubes of force and the ether, strangle themselves by their own inconsistencies. Every concept of science can be shown to be merely a link in an impotent closed chain. Without the concept of God these scientific concepts have no real significance. Many of the concepts, like the tube of force and the ether, are so grossly inconsistent and inconceivable that they must be abandoned if science desires to retain even a vestige of self-respect. Concepts like the tube of force and the ether are attempts of materialism to get along without the concept of God. These attempts have proved total fail-

ures. In trying to bridge the voids between matter groups by ethers and similar fantastic and irrational concoctions, science, by its own blunders, has led us face to face with the concept of God.

3. That the horror of materialism for the vacuum is at the root of its obstinate refusal to admit the possibility of action at a distance. Science, in committing the error of refusing to admit action at a distance, implicated itself in the more fundamental error of assuming that things are unrelated and independent. A rational world order cannot be constructed from unrelated independent things. We must admit the mutual dependence of all centers of reality in a world system which is unitary and interacting. If we do not admit this, then a physical universe is impossible. The unitary interacting system, composed of centers of mutually dependent reality, is itself merely an inoperative phantom of speculation without the concept of God's maintaining immanence within the system. Every physical action involves the possibility of action at a distance. Mere spatial contact affords no means of accounting for physical action. In a unitary interacting system maintained by the immanence of God, action at a distance is easily comprehended.

4. That the experimental method employed by science in its investigation of physical phenomena has brought great blessings to mankind. We give this method our hearty approval. Through this fruitful and sound method science has inadvertently and unintentionally reduced matter to a form of reality totally different from its own cherished notions of fixedness and eternal permanence. The atom has been shown to be composed of sub-atomic parts capable of mass variation with changes in velocity. The resistive ability of these sub-atomic parts, known as electrons or corpuscles, is all that remains of their materiality. The complete physical measure of the magnitude of the electron must involve the product of its two constituent variables, that is, mass and acceleration considered as two phenomenal aspects of a single unity. Science has given the name of force to this product. It is evident that scientific research has, consequently, dematerialized matter and given us a center of reality alien to matter and identical with force.

The vision of the great Jesuit physicist, Father Boscovich, has been unintentionally verified by the recent investigations of science. The force center of Boscovich is the ultimate unit of physical reality. Boscovich ascribed the property of inertia to his force center. This inertia of the Boscovichian force center corresponds to the resistivity of the primordial particle. The materialists have inadvertently given a spiritual significance to the physical universe. We cannot conceive a rational universe arising from an irrational activity principle. Therefore force is a manifestation of a rational actuating principle immanent in the physical universe. Consequently the concept of God becomes indispensable to the existence of the physical universe. Thus we observe that materialism has dug its own grave.

The above epitomized facts, together with the deductions therefrom, form the basis of the Space-Time Potential, whose salient features will now be considered.

23. Fundamentals of the Space-Time Potential.

The basic principles of the Space-Time Potential are:

1. The existence of God.
2. All reality owes its existence and maintenance to God.
3. The immanence of God throughout the universe, and also His transcendence.
4. The cosmos is a unitary, interacting, rational, purposive, and teleological system. It is a finite projection of the Infinite.

These fundamental principles, having been established by a process of deduction from the known to the unknown, constitute the fundamental truths upon which our system is based. Upon these basic truths we can construct a consistent model of the universe. If these truths are not granted, a consistent model cannot be constructed. These fundamental verities must be incorporated into any model of the physical universe if it is to be a true representation of a dynamic world of becoming and change.

The finite projection of God, manifest in space and time, may be subdivided into three worlds: (1) The World of Energy, Force, and Life; (2) The World of Conscious Selves; and (3) The World of Subconsciousness. The Space-Time Potential deals only with the physical universe,

Pantheistic
?

and hence its problem is the interpretation of the manifestation of God as the ultimate source of the Potential charted in Space and Time.

When we speak, in the third basic truth, of the immanence of God, we do not think of God as a machinist strolling about the universe with an ever-ready oil cup with which to oil the creaking bearings of the cosmic machinery. On the contrary, we think of the universe as a completed finite projection, capable of exhibiting through secondary causes those uniformities which we call natural laws, yet incapable of continuous existence in space and time without the continuous sustaining potential of God's unceasing existence. By "immanence" we mean the continuous dependence of the cosmos upon the Being of God. We also use the word "immanence" to convey the thought that God's interest in His created universe is continuous and does not cease with the act of creation. The dependence of the physical universe upon the maintaining activity of God is somewhat analogous to the steady flow of water in pipes due to the maintenance of an uninterrupted pressure-head. Remove the pressure-head and the water ceases to flow. Similarly, in the case of the flow of electricity, this phenomenon depends upon the continuous maintenance of a difference of electric potential.

24. The Existence of God Proved from the Facts of Science.

Physical Proof of the Existence of God.

The Space-Time Potential involves a physical proof of the existence of God. Science defines the potential energy of a body as being equal to the work required to bring the body from that position in which its potential is equal to zero to the point of known potential. Consequently the potential at any point is equal to the work done in bringing a unit mass from an infinite distance to that point. Now to bring a body or particle through an infinite distance requires an infinite time; therefore this hypothetical body has not yet arrived at its destination, and it can never arrive within the confines of this physical universe. To regard the universe as infinite merely makes the problem more impossible. Hence, whether we regard the physical universe as finite or

infinite in no way changes or affects the conclusion. It may be contended that this argument is worthless if it be assumed that the primordial elements have always existed and that for the elementals of the universe there is neither a time of beginning nor a time of ending. This contention in no way affects our conclusion, for the reason that whatever potential a particle may possess at any given point in space at any particular moment in time, this potential is equal to that which would have been produced if the particle had previously traversed an infinite distance in order to arrive at the given point. Now an infinite distance or time is not a completed something. The term "infinite" means nothing at all unless it refers to some type of process which cannot be completed. For this reason the appeal to an infinite time is futile. It follows that the observed potential of an actual particle or body existing in the physical universe may be attributed to the following sources:

1. To a motion of the particle through an infinite distance.
2. To an actuating and energizing agency within the system of the physical universe.
3. To an actuating and energizing agency without the physical universe.

We shall consider these possible assumptions in the order given.

1. We have shown that the first supposition is impossible because a motion through an infinite distance involves motion which cannot be completed in either finite or infinite time. Infinite distance or infinite time means that which cannot be completed. If it does not mean this, it has no meaning at all.

2. The injection of the idea that the particle is located an infinite distance from some given point is resorted to for the purpose of giving the particle a zero energy or potential value. The procedure therefore involves the further assumption that the potential energy of the particle has changed from zero potential to a potential other than zero. Was this change in the energy of the particle brought about by the particle itself or by some other particle? It could

not have been brought about by the original particle without ascribing to that particle the possibility of originating something out of nothing, in which case the result would be due to a genuine creative act, and the particle must, in that event, possess an attribute which we ascribe only to God, the Creator of all things. If we maintain that the potential of the given particle is due to the actual potential of one or more other particles, then we demand that the source of their potential be shown. An attempt to evolve the potential of these other particles involves the same fruitless procedure as for the given particle. The search through the universe for a particle or particles which can supply us with this initial source of potential is consequently futile. Therefore no particle exists within the physical universe which can supply us with the initial source of energy.

3. It follows that the observed potential of any particle or body existing in the physical universe is due to an actuating, energizing principle other than the mere physical constituents or force functions extant within the physical universe. Again we are forced to the conclusion that God, and God alone, is the source of the difference in potential existing in the physical universe as manifest in the Space-Time Potential. The dynamics of the physical universe, that is, the ability of particles to interact, depends upon the continuous maintenance of a difference of potential through the activity of God. This conclusion does not involve God in individual activities from particle to particle *ad infinitum*, but it does mean that the final potential difference ultimately reached is maintained by the activity of God. The universe is otherwise a complete uniformity within itself. We have therefore proved the existence of God by using the facts of physical science. Our reasoning is like that of St. Paul the Apostle, in his Epistle to the Romans, Chapter I, verse 20: "For the invisible things of Him from the creation of the world are clearly seen, being understood by the things that are made, even His eternal power and Godhead; so that they are without excuse." The existence of God has been proved by reasoning from the known phenomena of the physical universe. Without a difference of potential, physical action of any kind what-

soever is impossible. We have shown that from this fact it follows that the physical universe is impossible without the concept of God, and materialism has been shown to be the greatest fallacy of the ages.

The justification for the use of the word "potential" in our title is now apparent. The significance of the "Space-Time" in the title will be evident from the considerations which follow. In the first article we defined the fundamental concepts of science and showed that all the concepts are, in their final analysis, related to and dependent upon the notions of space and time. The term "mass" has been reduced to a force manifestation in space and time. The meaning of the terms "space" and "time" is therefore essential to our system.

25. Space Defined. *This is Kantian Subjectivism.*

Space is a "form" of apprehension or awareness which permits the intelligible relations of bodies to exhibit themselves to us as an externally ordered arrangement. Space, then, owes its full significance not only to the perceiving subject, but also to the existing intelligible relations between things.

26. Time Defined.

Time is a form of apprehension or awareness which permits the intelligible arrangement of events to be presented to us as interrelated, durational, and successional series. Both these subjective forms depend upon the intelligible coherence of all that is real as that basic element which generates them through interaction of subject and object.

With this view of space and time, action at a distance is readily granted. We have proved by a detailed discussion of the problem in our Space-Time Potential that actual physical phenomena are impossible without the admission of the possibility of action at a distance.

27. The Primordial Activity Center, The Monon.

The most elemental create reality manifest in the Space-Time Potential is the force center of Boscovich, to which

the writer has given the name "monon." The spatial background is a chart of potential energy values in which the kinetic energy centers, the monons, manifest at definite positions or points. The monons, in addition to being energy, are potential matter. Therefore we assign them the fundamental property or capability of exhibiting resistance to that which tends to give them acceleration; in other words, we attribute kinetic reaction to them as their basic phenomenal property. The monon is capable of exhibiting both a negative and a positive phase of activity. The negative phase appears as kinetic reaction or resistance. The positive phase, due to its intrinsic content of kinetic energy, is manifest as attraction. Both attraction and repulsion are included in the content of the monon. Since kinetic reaction involves a potential or possible mass coupled inseparably with a possible acceleration, we include these factors in the content of the monon with full realization that mass and acceleration are mutually dependent variables capable of all the shades of variability from a minimum to a maximum. Within certain critical values we may therefore find that the variation of mass of the monon is practically reduced to its zero limit; in other words, below this critical value the mass of the monon may appear to be maintained at a constant value.

28. The Energon.

The further development of our system requires that its kinetic energy be defined, in part, in terms of motion, for the reason that all mechanico-physical phenomena are ultimately reduced to terms of motion. This involves the existence of gyrational groups of monons. A rotary system composed of two diametrically opposite monons constitutes our simplest gyratory group. We have given the name "energon" to this gyratory group. Like the monon, the energon must include both attraction and repulsion in its content. In order to meet the requirements of certain class phenomena like the phenomenon of light, we consider these phenomena as being due to the interaction of a translatory system and a vibratory and translatory auxiliary system. To the former we give the name "excitant system," and to the latter we apply the term "concurrent system."

29. The Excitant and the Concurrent System.

The simplest physical phases of interaction are repulsion and attraction, reaction and action. These opposed forms of physical action represent the negative and positive phases of all types of reality regardless of complexity. The negative and positive functions are not independent existences; on the contrary, both are manifestations of a primary unity, the former insures the self-preservation and survival of the center of reality, while the latter provides for possible attractive manifestations. In physical action of a vibratory order the differentiation of the unity of physical reality into two systems of the excitant and the concurrent is in complete harmony with the basic facts of physical action, which always involve action and reaction. Both the excitant and the concurrent system are ultimately composed of the same kind of discrete energy group. We discard the notion of a continuum or ether, because of its many contradictory and ultra-material concepts. The same properties and laws of action pertain to both the excitant and the concurrent system. This gives us a hypothetical physical basis for a theory of relativity. The velocity of light becomes the limiting constant in the relativity system. Ultra-atomic velocities approach this limit but do not reach it. The constancy of mass disappears and its variable dependence upon concomitant phenomena appears as a real factor in physical change. In the mathematical portions of the Space-Time Potential the writer has developed the relations between mass variation, velocity in general, and the velocity of light. The results are in agreement with the researches of Kaufmann. The Space-Time Potential is a system of relativity.

30. The Three Phases of the Energon.

In order to account for physical action we assume that the energon is capable of change in a twofold manner from its neutral condition. Consequently there is involved an ascending process and a descending process. The former involves a definite work increment, the latter involves an equal work decrement. The three corresponding phases of the energon may be designated as the high, the neutral, and

the low phase. In the high phase the energon becomes an electron. In the low phase the energon becomes a "positon." The word "positon" indicates that the energon exists in that phase which is the extreme of the electronic. The primordial energon constitutes the neutral phase of the variable system. A negative charge is always associated with the free electron. We associate an equal positive charge with the positon. In the last analysis the magnitude of this negative and positive charge depends upon the work increment and its equivalent work decrement. Work expended is always equal and concomitant with work stored. Ions in solution exhibit these three phases in accordance with the precise phase change in the energon. Since all interaction presupposes the concomitance of both the ascending and descending processes, it follows that the products of solution must appear as ionic pairs. In this we have a consistent hypothetical reason why molecules break down into so-called ionic pairs.

31. The Planetary Orbits from the Standpoint of the Space-Time Potential.

One of the fundamental assumptions of the Space-Time Potential is that whatever laws pertain to the elementals of the universe, these laws pertain also to their aggregates irrespective of their magnitude. Consequently the story of the microcosm, the little world of sub-atomic particles, atoms, and molecules, is also the story of the macrocosm, composed of those great aggregates of elementals which we know as planetary and stellar bodies. Therefore any system which must introduce arbitrary constants in passing from the microcosm to the macrocosm in order to account for the gaping discrepancies between the enormous energies exhibited during interaction by the sub-atomic particles and those shown by ordinary physical bodies, cannot be a true representation of the physical universe. This is the case with modern science. This inconsistency is not encountered in the Space-Time Potential. The laws by which we interpret the activities within the microcosm are equally applicable to physical action in the macrocosm. We are not forced to inject arbitrary constants in order to bridge the enormous energy differences.

Our mathematical investigations, based upon the Space-Time Potential and agreeing with the results of research, bear out this contention.

32. Qualities Essential to the Monon.

We hold that the physical universe cannot be explained by mere number alone. Thomson has tried to build up the different types of atoms by increasing and decreasing the number of the constituent sub-atomic particles constituting his model. The procedure is analogous to the following:

One pound of sugar plus one pound of sugar equals two pounds of sugar. Two pounds of sugar plus one pound of sugar equals three pounds of salt. Three pounds of salt plus one pound of salt equal four pounds of salt. Four pounds of salt plus one pound of salt equal five pounds of pepper. In other words, the different types of atoms are due to a difference in the number and arrangement of the constituent particles. We contend that the primordial elementals possess characteristics and qualities which differentiate one elemental from another, and that the great diversity manifest in the physical universe cannot be accounted for by mere number and mechanics.

We realize fully the lack of continuity and convincing clearness which has been inevitable because of the brevity of this exposition. This difficulty we hope to overcome in the following chapters. We have attempted to indicate the fundamental elements in a physical system which depends for its significance upon the concept of God. We have tried to interpret consistently the phenomenal world and its activities. It is with a full realization that God knows better than we have presented this humble interpretation of His creative work.

CHAPTER II

SOME INCONSISTENT CONCEPTS OF MODERN SCIENCE

33. The Critique of Mathematics.

Modern science overrates the value of mathematics in the interpretation of physical phenomena. In very many cases the results of a mathematical investigation are postulated as physical realities. There is a great difference between pure mathematics and applied mathematics. Pure mathematics involves the forms of thought in their relations to space, time, and number. The fundamental premises required in the field of pure mathematics are grounded in the content of the rational mind. This is true irrespective of the manner in which this content has developed. Consequently the premises of pure mathematics are logically verifiable. In the field of applied mathematics, including physical science and engineering science, the premises cannot be verified through mere logic. They have no value unless they truly represent reality. The mathematical analysis may be correct, but the result is worthless if it does not agree with the facts of reality. This means that the premises were initially in error. Applied mathematics, therefore, is merely an *experimental* science by which we test the validity of the initial premises. The final test lies in the facts of reality. The hypothetical creations of applied mathematics are mere fictions possessing no value unless they are true counterparts of physical reality. Many of the "convenience unknowns" of physico-mathematics are worthless because they do not truly represent reality.

34. The Ether.

The ether is just such a "convenience unknown." It has been adorned with "well-defined" properties. Its physical content has been determined by the "rigorous method of mathematics." Imagine, for a moment, the reliability

of such a farcical procedure! Despite the fact that no physical counterpart for the ether has even been discovered, nevertheless the ether advocate knows both what it does and what it is. Of course, it may be many things, some of which involve extraordinary inconsistencies—in fact, self-contradictions of such gross proportions that if the ether were any of these alleged “somethings” it could not consistently possess certain other properties imputed of vital importance to its physical structure. The ether is an inferential unknown. Unlike matter, the ether cannot be observed by the senses. Consequently the physicist who ascribes definite properties, qualities, and mathematical content to the ether enters the very zone of speculation which he holds in such ill-repute.

35. Force.

When we consider the prevailing scientific notion of force we are confronted with a concept which is placed by science in the category of “what they do” factors. Through this expedient the physicist hopes to avoid the responsibility of defining his “convenience unknown.” Questions relative to “what it is” are lightly set aside as irrelevant even if somewhat irritating. Scientists seem to be in perfect accord with one another in defining force as that which tends to produce change in the state of rest or motion of matter. Physicists primarily regard force as the “mover” of matter, the active dynamic factor in the physical universe, an entity distinct from, but capable of acting upon, that other independent entity called matter. We are here confronted with a dualism of matter and force. Has it been possible for science to adhere strictly to its self-imposed attitude of refusing to consider the problem of what force is?

36. Tubes of Force.

Maxwell and J. J. Thomson, employing the primary concept of Faraday's lines of force, developed systems which make it possible to consider mathematically the quantitative relations obtaining in magnetic and electric phenomena. J. J. Thomson, in attempting to visualize the activity factor called force by science, adopts the electric line of force as

the unit from which the so-called Faraday tubes of force are constructed. He considers a charged body (whatever that is) to have its external surface divided into small areas, each exhibiting the same amount of charge. Emanating from the boundary lines of these small areas are lines of force which enclose regions of tubular configuration constituting the Faraday tubes. The system is completed and becomes active when a second body is introduced upon whose surface the other, previously unemployed, ends of the lines of force can rest. These opposite ends, immediately upon the entrance of the second body into the system, seek out areas upon its surface; arranging themselves methodically along the boundary lines. This performance is concomitant with the appearance of an electric charge upon the small areas of the second body. This secondary electric charge upon the small areas bounded by the tubes is of equal magnitude but opposite in nature to the charge upon the surface of the first body. We are curious to learn if the secondary charge either lurked in the vicinity of the second body or within its confines before the tube pounced upon its victim. Perhaps this secondary charge was merely a possible charge which became real the moment the tube touched the surface. Possibly we ought to consider that it is the tube that constitutes the charge and that the two ends thereof agree to differ. We may be unfair in our questions; for, is not the word "concomitant" sufficiently awe-inspiring to prohibit levity in any form, and cannot so potent a word annihilate all tendencies to inquire into physical antecedents and relationships? In fact, it is maintained that all that is meant by a charge on a body is that a Faraday tube ends upon its surface. Moreover, the motion of a Faraday tube is what constitutes the flow or passage of an electric current.—This hypothesis regards the phenomena of electrostatics as cases of tubes at rest. The notion that opposite charges exist at the opposite ends of the tubes involves the hypothesis in difficulties which have made it necessary to modify the original conception, resulting in the supposition that each charge is attached to a distinct and separate tube which is its own individual property. A charged body differs, then, from an uncharged body merely in the fact that the charged body carries a

supply of Faraday tubes protuding from its surface much like the quills of a porcupine. A Faraday tube cannot be a general prototype of force, because if such is the case, then every physical phenomenon involving a manifestation of force would also exhibit that physical or metaphysical something called a charge. Consequently force in the form of a tube must be a distinct force species which exhibits an electrical charge. A charge-tube, then, is as distinct a type among force forms as the porcupine is among animals. A cross section of a Faraday tube, no matter where taken, exhibits merely lines of force. The cross sections may differ in their form and size, but not in the fact that an area is bounded by lines of force. Nevertheless, we are requested to concentrate our attention upon the ends of the tubes, for it is there that the charge either resides or appears. However, a material aggregate is necessary for the appearance of the hidden factor called the charge. We are decidedly out of order if we impertinently inquire whether the charge is located somewhere in the tube, or somewhere in the body, or possibly in neither tube nor body. Possibly the hole in the end of the tube constitutes the charge. Perhaps the particular shape of the tube end is an electrical charge. It may be that the tube is like a magic wand, and that the moment it touches a matter aggregate a charge appears. If this is true we ought not to insist upon knowing the wherefrom or nature of the charge, for that is not customary in fairyland.

The tube itself must be in its real essence entirely distinct from matter. The lines of force must not be thought of as a definite configuration of material particles, for such a conception would make the term superfluous. The lines should be considered as being spatial stress directions independent of the presence or absence of matter in the path of stress. Do the tube advocates remain content with this notion? We are told that tubes of force, in order to play their rôle properly, must be considered as being subjected to tension in a longitudinal direction, thus producing a decrease in the length of the tube. When the ends of the tube lie upon a body which is insulated, this contraction is considered as being impossible of accomplishment because the ends are so firmly fixed to the insulated body that with-

drawal is impossible. A splendid mechanical model of this latter case, if this is desired—and it seems to be the sole purpose of the tube notion—can be constructed by using wire to represent the lines of force and hollow bodies for the charged bodies. If, then, the wires are riveted on the inside of these shell-like bodies, we have the case of tubes of force attached to insulated bodies. The fact is that some such notion must actually accompany this concept, for how can we otherwise conceive the permanency of the contact between tube end and insulated body? The difficulties involved in this latter hypothesis are trivial in comparison with the notion of a state of tension existing along the length of the tube. We can readily conceive of a state of tension existing along some particular line in a material body, in which case science at once introduces the term "force," or some similar term, to account for the existence of this particular type of disturbance. Are we, then, not well within our rights if we demand that the tube advocates exhibit to us a secondary force as the real activity agent in this phenomenon of force tube tension? Thinking in these scientific terms, it would not be entirely inconceivable to imagine the case of a tube of force contracting under the influence of an external force influence, provided that we did not inquire how this phenomenon would be accomplished.

To remain a scientist and think that the tube of force could contract itself would be far more inconceivable. It would be far more consistent to refrain from materialistic particularization and be content with the notion of force as synonymous with a deiform mover which, when acting upon material groups, can cause them to approach each other or depart, depending upon the exigencies of the case. However, this would not be a scientific attitude, for in science something always acts upon something else in accordance with the principle of conservation. It would be nothing less than scientific heresy to assume that a given something can act upon itself—indeed, must act upon itself—before it can produce effects upon things other than itself. Nevertheless, the Thomsonian tube hypothesis does just this. In his desire to visualize this particular group of phenomena,

Thomson requests us to pin our faith in the first place upon the tube's ability and willingness to contract; then we are properly prepared to accept the second part of the performance, which pertains to a spatial change of position of the involved material groups. It may be that Thomson belongs to that school of physics which denies dealing with causes. If this is the case, the contraction of the tube would be designated as being the physical antecedent of the subsequent observable modifications in the matter groups.

At one time it was considered sound reasoning to suppose that the earth was sustained by a large tortoise. This one in turn was supported by another and larger one, and so on *ad infinitum*—which means until you become weary of asking the same question over and over again and receiving the same answer. Finally, when your patience is exhausted, the elephant is brought upon the scene and the last tortoise is then gently placed upon the back of this most adequate beast, whose ability to carry the burden of the proof must remain unquestioned.

If, however, the Thomsonian tube is the first and only tortoise, then we can clearly understand why the occult power of self-contraction must be ascribed to it. This power alone is not a sufficient equipment for a well-behaved tube. It must be able to distinguish and discern between matter groups, it must be able to play a definite, consistent rôle in the scheme of things; in fact, *it must be a knowing, conscious organization*, otherwise it may readily be conceived that, at some ill-chosen moment, the tube would fail to perform in a decorous manner, or cease its functioning entirely.

Thomson, therefore, in finding it necessary to ascribe the function of self-contraction to the tube, has entered the sphere of "what force is." If that is metaphysics, then Thomson is a metaphysician. It may be retorted that Thomson is well within the bounds of the "what it does," for in his very assumption he merely maintains that the tube "does contract." A fine quibble, indeed!—for what can be meant scientifically by "what it does" except the disturbing influence of the "it" upon other things or "its" in a genuine objective world. Consequently, if the "it" does something to itself, *then the scientist has ceased to deal with*

the cold, unconscious factors of a material universe, and he has inadvertently hurled himself into the domain of the volitional and, at least, selective consciousness.

37. The Erroneous Dualism of Science.

The phenomenal world for Thomson is, then, dualistic in its final analysis. Phenomena are the products of the action of force upon matter. Mathematically considered, force is a compound unit involving the product of mass and acceleration. This mathematical definition can mean nothing if it does not mean that the magnitude of a "force" is measured by the accelerative effect which it exerts upon a given quantity of matter. Force, then, is an inferential causal factor in the phenomenal series. The overcoming of force through distance is known in physical science as "work," while the ability to perform work is classified under the category of "energy."

We challenge the correctness of the dualistic position which regards force and matter as two distinct entities. We maintain that the only consistent position is the one which admits the identity of the two in a genuine monon, or force center.

38. Matter and Force.

This problem is not a product of modern science. It dates back to the earliest thought of which we have any records. The problem of matter and force has interested the human intellect from time immemorial. The early thinkers asked themselves the question, What is the nature of matter and what are the ultimate constituents of material things and objects? Observations of matter in motion, in contradistinction to matter at rest, led to the concepts of cause and effect. A causal principle was required to account for the change of state from rest to motion. Hence the invention of a second principle or entity called "force" by modern science. The more primitive notions were veiled in a mythological atmosphere. The manifestations of force or energy were regarded as the work of gods or demons. Systems of philosophy arose later dealing with the problems of matter and force. Science and philosophy, physics

and metaphysics, had not at that time parted ways. Science and philosophy were almost synonymous in content and purpose. The modern scientific method, involving a correlation and interpretation of experimental facts, was as yet unknown.

39. Ancient Cosmic Theories.

About 1200 B. C. the Phœnicians Sanchoniatho and Ochus evolved a materialistic conception of the universe. The Stoic Posidonius speaks of Ochus as the first originator and enunciator of an atomic theory of matter. The Chaldeans, Egyptians, Persians, and Chinese evolved cosmic theories abounding and veiled in fable and mythology. In India, many years before Christ, we find the Brahmins, Vedantists, and Buddhists discussing the nature and significance of matter. About 600 B. C., Thales, the Greek philosopher, reduced the world to an original element, water, from which all things emanated and everything was divine. He did not attempt to define his concept, but named it *ὕπερπον*. About the year 500 B. C., there flourished at Elea, in Italy, a school of thinkers who asserted that the world of things was one of appearance whose real nature could be ascertained only through understanding and reason. Xenophanes, the founder of this school, held that all things are eternal and immutable. To account for the multifarious changes in things, he assumes as primitive elements water and earth. Parmenides, also of the Eleatic School, distinguished between apparent knowledge and true knowledge. Apparent knowledge came through the senses, while real knowledge resulted through reason. To account for the changes in the physical universe he introduced two principles, that of heat or light, a positive element, and that of cold or darkness, a negative element, or, as he preferred to style it, a limitation. In the philosophies of the East Indians we also find the concepts of affirmation and negation playing an important rôle. It remained for Hegel to round these thoughts into a comprehensive system.

Heracleitus, a profound thinker of the Ionian School, also made it his object to discover an elemental principle which he assumed to be fire, because this was, for him, the most subtle and active of all the elements. Fire, he main-

tained, was at the foundation of all things, and, consequently, it was the universal agent in change. According to Heracleitus, the universe was neither the work of gods nor of men, but consisted in this elemental fire, which continually kept alive. The changes noted in things he attributed to fire, which caused formation as well as dissolution. The important fact in the universe was this very transformation, change, or flux of things. Becoming, not being; change, not static existence, was the essence of that which constitutes the reality of the universe.

Leucippus, a contemporary of Parmenides, about 500 B. C., announced an atomic theory of matter. The world, as seen by Leucippus, consisted of a countless number of imperceptibly small particles that differed only in form, position, and size. Leucippus called these particles *ἀτομοί*, or atoms. To them he ascribed the power of self-motion. Whirls and vortices were formed by the coming together of these darting, moving particles. Thus entire worlds were formed. The nebular hypothesis of Kant, Laplace, and Swedenborg was, consequently, antedated by Leucippus by some 2,200 years.

Democritus, the brilliant disciple of Leucippus, maintained that inertia, or degree of mechanical movability, density and hardness were properties of things. From the two fundamental concepts of matter and motion, Democritus built his world system.

After the time of Democritus, very little, if any, advance was made in the theory of atomism until in the sixteenth century A. D., when the Italian Giordano Bruno connected his conception of the monad with that of the atom of Leucippus.

It remained for Leibnitz, the inventor of the infinitesimal calculus and the originator of the conception of "vis viva," to perfect the notion of a force substance in his Monadology. The monad of Leibnitz is essentially a center of force. He sought the ground of the motion of bodies not in their extension and mass, but in their ability to do work.

The brilliant Jesuit mathematician, physicist, and astronomer, Father Boscovich, with keen prophetic vision, developed the concept of the force center to its fullest excellence. In more recent times we find Ampère, Faraday, and

Fechner advocating this same theory in certain phases of their thinking.

40. Dalton's Atom.

In the year 1803, Dalton, employing the modern scientific method, introduced the "Law of Multiple Proportions," thus giving a fixity and definite individuality to the atom. Avogardo, employing the scientific method, introduced into science a new term, the "molecule," in distinction from the term "atom."

41. Kaufmann's Researches.

The fixedness given to the notion of mass by the contributions of Dalton and Avogadro was forever shattered by the brilliant researches on Beta rays by Kaufmann (1902-1906). Kaufmann showed that as the velocity of the Beta particles approached that of light, the mass of the particles approached an infinite magnitude. The common inference from this discovery is that an infinite force is necessary to give to a particle the velocity of light; and, furthermore, the erroneous conclusion is that light cannot be a manifestation of material particles.

42. The Two Alien Entities of Science.

In its atomistic garb, matter assumed such dignity and importance that the notion became the father of the modern materialistic school of philosophy. Matter in motion, however, as the paramount datum of experience, proved itself a difficult notion for science to solve. The idea of activity of matter contained a further notion of a factor unlike matter yet operating in conjunction with matter, producing the phenomena of motion of matter in space. The primary experience datum has the semblance of a compound composed of a distinct and independent active factor and another separate entity whose nature is wholly passive. The term "energy" has been introduced by science in order to place an exact label upon the active factor. We find the term "force" used frequently in a synonymous sense to designate the activity factor in the universe. The exact scientific definition of energy involves two factors, mass and the

square of the velocity together with the constant $\frac{1}{2}$; while force is defined as the product of mass and acceleration. The independent activity factor, whether it be called energy or force, is defined by physics in terms of the other independent and passive factor mass. Science by this very act admits the impossibility of isolating the two factors as independent existences, nevertheless, by universal consent they are so regarded. The Faraday tube of force, previously considered, is a definite example of how science clearly dissociates the two notions and regards them as distinct entities having equal claims upon reality. In order causally to account for physical phenomena, science introduces an inferential X , a conceptual something to bridge the glaring gaps in the physical series. Thus arose the dualistic theory of matter and force as the two separate entities from whose mutual action phenomena are produced. The task of science has been to arrange an act between these two entities, perhaps alien and inimical in their real nature, upon the stage of phenomenal experience, with space, time, and causality as the scenery. The task has proved of herculean proportions, and a resort to a "psycho-physical" force composed of kinetic energy and intelligence cannot overcome the difficulties involved, even if such a term be given its broadest possible significance, if it be regarded as an entity or being independent of matter.

This dualistic theory continually involves science in an unending chain of difficulties. Force must find its way from one group of matter to another; it must make itself known from one material aggregate to another such aggregate. As a consequence of these difficulties and problems there arose the much mooted question whether forces can make themselves known at a distance without the intervention of a transmitting vehicle or medium, or whether force effects must have a medium through which they can travel from one group to another.

43. The Unifying Principle.

In the preceding chapter we have seen some of the inherent weaknesses of the materialistic position. The tube-of-force concept involves insurmountable incompatibilities. To make it operative at all, *selective intelligence* must be

introduced into the notion. However, materialism refuses to countenance any conceptual content which involves something other than mere mechanism. Nevertheless, "something other than mere mechanism" must be introduced into the groundwork of the universe in order to explain physical action. Moreover, it is impossible to regard force and matter as independent entities. Materialism has utterly failed to show us the *modus operandi* by which interaction between those two alien entities may be established. A unifying concept is absolutely necessary in order to make physical action possible. Selective intelligence, which even the rabid materialist must include in all his concepts, involves the admission that reason and intelligence constitute the foundations of the cosmos. In the world of purely physical phenomena determinism governs activity. The physical universe is, consequently, a world of secondary causes. Therefore, we do not countenance the idea held by some thinkers that selective intelligence involves conscious will. The physical elementals of the universe give us no indication of the slightest trace of conscious life. Therefore we are forced to the conclusion that the imprint of deterministic character exhibited by the physical elementals is an endowment assigned to them by the Creative Divine Intelligence. The deterministic characteristics of the primordial elementals are merely a part of those unified rational activity relations which we record as the physical story of a rational cosmos. Consequently this record is written in terms of natural laws. In the introductory chapter we have shown that the admission that reason and intelligence are necessary for the explanation of physical phenomena involves the further admission of the existence of a Creative Divine Intelligence. Furthermore, the concept of God furnishes us with the only unifying principle capable of accounting for the law-ordained interaction between primordial elementals which would be incapable of such intelligible interaction if they are regarded as the independent entities erroneously isolated by materialistic science.

CHAPTER III

ACTION AT A DISTANCE AND THE ETHER HYPOTHESES

44. Action at a Distance.

Some two hundred and fifty years ago, the scientific world found it difficult to conceive the idea that matter can act where it is not. At that time the motions of the planets were explained by a mechanism of cycles and epicycles. This system was slightly improved by Descartes, the French philosopher and mathematician, by introducing the conception of "vortices." At the time of its introduction to the scientific world, the Newtonian doctrine of gravitational attraction met with stubborn resistance. In a letter written by Voltaire in the year 1727 reference is made to this resistance. Voltaire, having just visited England, wrote: "A Frenchman who arrived in London finds a great alteration in philosophy, as in other things. He left the world full; he finds it empty. At Paris you see the universe composed of vortices of subtle matter; at London we see nothing of the kind. With you it is the pressure of the moon which causes the tides of the sea; in England it is the sea which gravitates toward the moon. You will observe also that the sun, which in France has nothing to do with the business, here comes in for a quarter of it. Among you Cartesians all is done by impulsions; with the Newtonians it is done by an attraction of which we know the cause no better."

The much mooted question of action at a distance disturbed the scientific world over two hundred years ago and divided it into two camps.

Stated concisely, the question is, Can matter act where it is not? Must discrete portions of matter be connected by an intermediate something, an *X*, a medium, plenum, or ether, by means of which one material system can be placed, as it were, *en rapport* with another distant material system? Daniel Bernoulli answered the former question in the affirmative and denied the necessity of a gravific

medium in a letter written in 1744 to the mathematical physicist Euler. Father Boscovich, in a work entitled "Theoria Philosophia Naturalis," published at Vienna in 1758, maintained with Daniel Bernoulli that action at a distance was possible through an absolute vacuum. For him matter consisted merely of force centers endowed with inertia, and all physical and chemical activities were explainable as mutual attractions and repulsions, varying in intensity with the magnitude of the intervening distance.

45. The Medium of Faraday.

Later the brilliant investigator, Faraday, combated the doctrine of Bernoulli and Boscovich and infused new life into the medium hypothesis by his researches into electrical and magnetic phenomena. In fairness to Faraday we must quote the following, in which he refers to the notion of a corporeally extended atom: "What do we know of the atom apart from its force? You imagine a nucleus which may be called *a*, and surround it by forces which may be called *m*; to my mind, the *a*, or nucleus, vanishes and the substance consists of the powers *m*. And, indeed, what notion can we form of the nucleus independent of its powers? What thought remains on which to hang the imagination of an *a* independent of the acknowledged forces?" This is a most remarkable and clear statement of what everyone must admit is the true condition of our knowledge of corporeality. However, Faraday's difficulty consisted in arranging mutual action between these force centers. He therefore advocated the notion of a medium as the necessary link which could make possible mutual action between force centers.

46. The Ether of Clerk-Maxwell and Hertz.

The cause of the ether hypothesis was furthered by the mathematical investigations of Clerk-Maxwell and by the researches of Heinrich Hertz upon the velocity of propagation of electro-magnetic effects. The conception of electro-magnetic propagation in the ether is due principally to the nineteenth-century school of physicists.

The advent of the corpuscular or electronic theory of

matter has cast doubt upon the efficacy of a plenum or ether hypothesis to explain the many new phenomena discovered in the domain of electrophysics and electrochemistry.

47. The Field of Force and its Implications.

The followers of Faraday and Clerk-Maxwell still continue to deny the possibility of action at a distance and assert that electrostatic and magnetic attractions and repulsion are due to the stress or pressure action of a field of force which surrounds charged or magnetized bodies.

It is pertinent to ask the followers of Faraday what they mean by the term "field of force." Is it a reality in the external world, or is it merely a thought phantom conjured into merely conceptual existence as a mathematical necessity? If we read about "field of force" in works on electricity and repeat the term a sufficient number of times, it becomes, after a while, a mental friend which assumes, perhaps, unwarranted proportions of reality. Add to this pictorial illustrations of "tubes of force" bedecked and adorned with mathematical symbols of exactness and finality, and we are brought face to face with a powerful Goliath able to crush out and extinguish those impulses of common sense which demand a counterpart in the physical world for the magic phantoms of a fertile mathematical imagination.

Two possible answers present themselves to my mind like the horns of a dilemma. On the one hand, the followers of Faraday can maintain that by "field of force" they mean an active energized ether—whatever that is—or, on the other, they may hold that the term is merely a mathematical invention, a conceptual creation in the nature of a last resort when face to face with problems of ultimate reality. There are many who do not hesitate to label such conceptual creations as "metaphysical" plus a tinge of pity and scorn for the originator: a most curious attitude, in view of the fact that science itself is replete with metaphysical conceptions which pertain to hypothetical causal factors not known to sense perception. However, since "field of force" is a well-established scientific term possessed of a perfectly respectable ancestry, we are given to understand that we

must be very careful lest we commit the unforgivable sin of assigning this term to the category of the metaphysical.

Let us assume, then, that "field of force" is not a "metaphysical" will-o'-the-wisp changing with the physico-mathematical fashions, but that it is a genuine reality in the external world capable of performing the gyrations and contortions required of it by physical phenomena. An inquiry into the nature of this reality is then pertinent. Is "field of force" matter? Is it non-matter (shall we say spirit, soul, ultimate essence, absolute, or what not?); or is it a subtle something neither matter, as known to our senses, nor vacuum, meaning complete absence of matter? Shall we take the term at its face value, and suppose that the three-dimensional expanse of space is the sporting ground of forces which romp and prance about, attaching themselves ever and anon to alien, uninterested particles of matter whose nature is antipodal to that of force?

If the field of force is composed of matter, then the nature of the stress exerted by it, which is assumed to be the cause of the attraction or repulsion, must be explained. In other words, the mechanism by which surrounding matter causes stress or pressure to be exerted upon the surrounded matter must be shown. Even if this be possible, we are at a loss to know what advantage has been gained by substituting the term "stress" for that of attraction. It seems that one inexplicable term is of as little value as another, or even as any third which can be invented as a substitute for both.

Suppose that we assume that the field of force is a subtle something, neither matter nor non-matter, but a plenum, medium, or ether. This assumption leads us to the consideration of the continuity or discontinuity of matter. If we maintain that matter exists continuously throughout space, and we still find need for an ether to perform activities unassignable to matter, then we are forced to hold that ether and matter coexist in the same space. This thought, aside from being repugnant to sound reasoning, involves so many difficulties even for the ablest mathematician that very little can be expected from such an hypothesis. We must demand consistency from any hypothesis. If ether is a genuine

something, not force, energy, spirit, or thought—in other words, a real substance differing in its nature from matter, yet actually existing in space, which involves occupancy of space—then ether and matter cannot coexist in space even if mathematical manipulation can find a way to surmount the other difficulties involved in this conception. It is folly to expect a physical counterpart for every imaginable mathematical expression. It is the part of wisdom to condense actual physical phenomena to the shorthand of mathematical expressions.

48. Matter Regarded as Distinct from Ether.

The remaining alternative is that matter is discontinuous and that ether exists where matter is not. We must then assign one set of properties to matter and another set to ether. These properties must be capable of taking mutual cognizance of each other. The mechanism by which this cognizance becomes effectively operative must be set forth. Furthermore, we must assign to the ether some definite content if it is to be even a factor in thought. If it is not assumed to be some form of matter—make it as subtle, elusive, rare, and minute as you please—then it must be placed in some entirely different category from matter; in other words, if the ether is not some form of matter, it must be akin in its nature to force, energy, mind, or spirit, in which event we eliminate the spatial attribute entirely.

49. Matter Regarded as Ether in Motion. The Theories of Euler, Helmholtz, and Kelvin.

In order to obviate the difficulties encountered in both the above-mentioned suppositions, a radically different solution has been put forth in recent years. This involves the notion that all is ether, that there is no such substance as matter distinct from and independent of the ether, and that the ether is an ideal incompressible fluid. Euler investigated mathematically the possibilities of motion in such an ideal fluid. He cared little, as many other mathematical physicists have done, whether the physical counterpart of his ideal fluid could be shown to exist. For him it was a thought-phantom, with which to play at the game of mathe-

matics. Thought-phantoms oftentimes become genuine realities to the best-disciplined physicists if they happen to meet mathematical requirements. Von Helmholtz's considerations of the ideal fluid of Euler led him to propound the theorem that rotation, once established in such an ideal fluid, is unending, while particles which do not rotate from the beginning can never be set in rotation. These doctrines in the hands of Lord Kelvin were developed into the theory of vortex atoms, which, according to Kelvin, are spinning gyrostatic elements of ether in the ether.

50. Karl Pearson's Ether Hypothesis.

Kelvin's theory, although a most ingenious mathematical creation, nevertheless involves the same insurmountable difficulties as are found in all the ether hypotheses. Karl Pearson has put forward another ether hypothesis differing from Kelvin's in the *modus operandi* of its atoms, but in complete accord with him in regarding matter as merely an ether disturbance in the ether. Karl Pearson, however, shows sound sense in disclaiming external reality for his thought creation, and he distinctly states that the ether is nothing more than a conceptual limit of our perceptual experience.

51. The Inconsistent Content of the Ether Hypothesis.

The ether is a thought creation intended to bridge the chasm between material bodies and particles and to make explicable the phenomena of the physical world. Primarily, then, it is a thought concept, an hypothesis of which we must demand self-consistency. All advocates of the ether hypothesis agree in maintaining that the ether is a perfectly homogeneous fluid not made up of discrete parts like that other fluid, water, with which we are so familiar. When the discrete particles of water are set in motion a current or stream of these separate particles can be seen. How can a perfectly homogeneous fluid not composed of separate parts ever make manifest to the senses any changes, rotations, gyrations, or displacements taking place within it? The ether is a weightless something filling all space. It is isotropic, that is, it has the same properties in all direc-

tions. It is incompressible. These properties are common to all ethers, and the brands are numerous. Differences of opinion exist, however, in regard to the other properties of the ether. Maxwell gives the following values:

Density of the ether = 106×10^{-20} | (water = unity).

Modulus of rigidity (in C.G.S. units) = 955.

Modulus of rigidity of glass in the same units = 24×10^{10} .

Density of the ether = $1,000,000,000,000,000,000$ (air = unity).

Rigidity = $240,000,000$ (glass = unity).

These corrected Maxwellian values assume the amplitude of an ether-wave as $\frac{1}{100}$ of its wave length. It is equally correct and admissible to assume the amplitude as $\frac{1}{100,000}$ of its wave length. For this supposition the density of the ether becomes $\frac{1}{1,000,000,000}$ of air and its rigidity equals $\frac{1}{240}$ of glass. The enormous inconsistencies of the hypothesis make it unnecessary to split hairs in regard to the decimal places in the above values. As a medium of excitation of mathematical imagination the ether stands without a peer in the history of physical science.

If the density ascribed to the ether is either of the above values, it must be the rarest of all gases. A gas of such rarity cannot be imagined with discrete parts separated by great distances. This conclusion contradicts the assumption that the ether is continuous throughout space. Moreover, it vitiates the hypothesis of incompressibility. In the face of these facts, Maxwell did not hesitate still further to torture the ether in order to force it to account for gravitation. Consequently he assumed that it was able to withstand a pressure of 37,000 tons per square inch in a vertical direction and a tension of the same amount in a horizontal direction. When we compare this with the rigidity of high carbon steel having an ultimate strength of 50 tons per square inch, we wonder how it is possible for bodies to move about in this all-pervading ether with such consummate ease. Physico-mathematics does not always trouble itself with the demands of common sense. It is known that the planets and the atoms move through space with a freedom which forces us to assume that it is absolutely empty.

52. A Critical Analysis of the Ether Hypotheses.

Hertz has clearly set forth the requirements of the ether in order that it shall be capable of explaining the phenomena of electromagnetics. An impartial common-sense examination of the Hertzian disquisition in regard to the propagation of electric disturbance in the ether cannot result in anything but a verdict against the ether as a rational hypothesis for the explanation of these phenomena.

HYPOTHESIS I, CASE I

A logical analysis of the possible conceptions concerning the nature of the ether brings before us two distinct hypotheses.

The first hypothesis considers the electrical disturbance as being due to the combined action of two distinct factors—a medium and the effect of action at a distance.

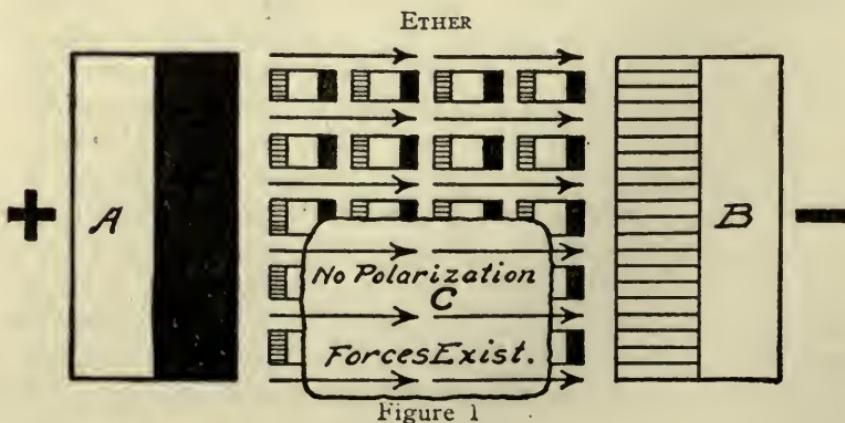
The basic postulate is that space is nowhere empty, but is filled with a mysterious substance or something called ether. Under the first hypothesis we find two related cases.

First Factor. Action at a distance considered as the large factor.

Second Factor. Effect in ether regarded as the small factor.

Assumptions

It is assumed that the acting force produces a change, called polarization, in the smallest parts of the medium. In Fig. 1 we show diagrammatically the conditions supposed



to obtain in Case I. In this diagram, *A* and *B* represent two oppositely charged bodies. The intervening space is the particular abiding-place of the ether. The small rectangles represent ether particles. The fact that a different state or condition exists at the opposite extremities of these ether particles is indicated by a cross-sectioned surface and a full black surface. The space *C* shows the existing conditions when a portion of the ether is removed in the space between the bodies *A* and *B*. The positive and negative electricities are shown upon the two bodies *A* and *B* by the same conventional method used to indicate the opposite states of polarization in the ether particles. The force exerted between the two bodies is indicated by arrows. The ether or electric fluid between *A* and *B* is regarded as an absolutely continuous isotropic substance. It is supposed that if a portion *C* of the ether is removed the forces within the space *C* remain unchanged, but the phenomenon of polarization disappears with the removal of the ether.

Implications

Every ether hypothesis insists upon the fact that the ether is a continuum. Indeed, this is its principal function and purpose in physical science. In other words, the ether fills space. Consequently human intelligence can readily subdivide the ether into continuum areas of the most minute dimensions. A vacuous space can be similarly divided by the imagination. However, we need not expect more of the little imaginary ether areas than we expect of the vacuum areas. The little ether areas will not show animal propensities, they will not perform, they will not become individuals, they will not polarize just because the human imagination has created them. Human imagination does not create life, it does not cause genuine entities possessing well-defined properties and functions to come into being. If the ether is a continuum, it will always remain a continuum. If it is a discontinuum, then it is a form of matter, however subtle and refined, and it is then composed of genuine disparate physical parts. If it is still maintained that distinct and individualized parts do exist in this continuum, then the ether advocate must not keep us in total darkness in regard to the nature of that choice which determines the physical

magnitude of these ether spaces. Does the ether, by the use of intelligent volition, determine the precise boundaries to its own little subdivisions? Are the physical dimensions equal or unequal? Is the process one of blind chance, or do the bodies *A* and *B* play a part in the unique drama? Moreover, we are not content with the mere term "polarization" as an explanation of a condition or state supposed to come into existence upon these subdivisions if such parts actually exist at all. The very vagueness of the term may be the satisfying element to some, but it should not be acceptable to the scientist who prides himself upon the wonderful mathematical accuracy of all his intellectual inventions. If "poralization" means anything at all more than a convenient highly unscientific artifice, it must mean that two antipodal conditions exist upon diametrically opposite portions of the little subdivisions. Of the infinite number of possible diameters, which one will prove to be the favored and the chosen? Does the imaginary subdivision do its own selecting of such a diameter? Perhaps the ether as a whole directs the maneuver. Possibly the body *A* or the body *B*, or both, or something entirely outside of the system, exerts its potent intelligent will telepathically in this mysterious selection. All these conjectures may be fatuous errors. An unseen, seen, heard, or unheard of force may be the directing and guiding influence in this ethereal phenomenon. By what mechanism, may we ask, does this force produce changes in the ether particles? Our inquisition is not complete unless we insist upon being informed in regard to the precise nature of the two antipodal conditions created in this homogeneous isotropic plenum. Is one condition compression and the other tension? Has the ether substance undergone a change in its very nature so that the antipodals are structural opposites? Do the diametrically opposite ends vibrate at different rates? It may be that a something has attached itself to one end, and an entirely different something has simultaneously affixed itself to the other end. Why not assume, in order to simplify the problem, that a state of joy exists at one end and a state of sorrow holds forth at the other? From the standpoint of æsthetics it may prove more impressionistic to suppose that one end is white and the other black.

It may be said that we are entirely too severe in our innuendoes. Drastic measures, however, are required to subdue that spirit of intolerance in science which prohibits, either by ridicule or by willful disregard, the open, unbiased discussion of the validity of the basic concepts which form the very foundation-stones of science. The utter carelessness with which modern science creates new convenience concepts, without in any way relating them to a real world and without any semblance of exactitude and consistency in the content of such concepts, is certainly deplorable. Intrenched within the fortress of experimental investigation, the scientific method can defy the attacks of superstition and emotional traditions. Nevertheless, a consistent science, a progressive science, a science of the future, if it is to employ in its edifice concepts which bring it into immediate rapport with the living, conscious world order, must not ignore the logic of philosophy and metaphysics in any attempt to construct a consistent cosmic system.

53.

HYPOTHESIS I, CASE II

First Factor. Action at a distance considered as the small factor.

Second Factor. Effect in ether regarded as the large factor. This case is shown pictorially in Fig. 2.

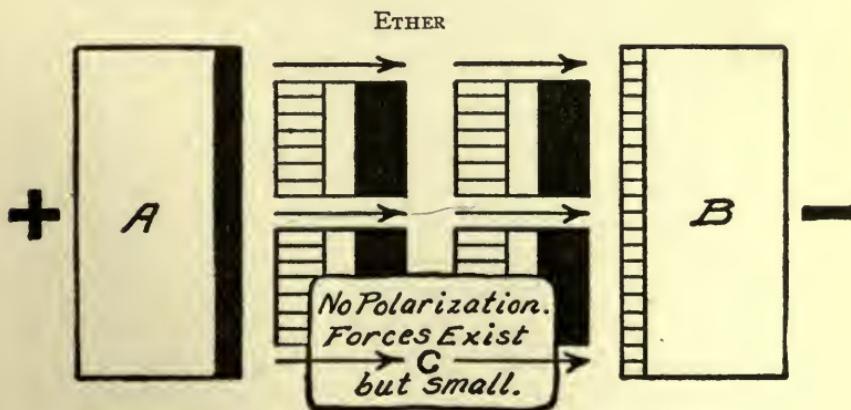


Figure 2

Assumptions

For this case the action at a distance effect is considered as merely a nominal factor. The charges on the bodies *A* and *B* exist, but they are small. It is assumed that the electricity of the medium is displaced toward the action at a distance effect, thus neutralizing this latter effect to a great extent. It is, moreover, supposed that the medium exerts a pressure on account of the attraction of its internal electrifications, which, in turn, tends to draw the bodies *A* and *B* together. The forces are still imagined to exist in the empty space *C*, although they are considered as vanishingly small. As in Case I, no polarization is assumed in the empty space *C*. Helmholtz developed this view for the entire field of electro-magnetic phenomena. Poisson employed it for the statistical phenomena in magnetism, while Mosotti found it useful in the explanation of electrical phenomena.

Implications

What real, definite meaning shall we place upon this conglomerate mass of words? It all sounds very technical, abstruse, and therefore very sane. Indeed, we are upon holy ground and should have some reverence for such glorious and profound words as "electricity of the medium," "neutralization," "internal electrifications." Such wonderful words ought to possess sufficient inherent power to drag any two bodies together, no matter what distance or obstacles may intervene.

What genuine, clearly defined concept shall we affix to the combination of words "electricity of the medium"? While our attention has been distracted, our friend the scientific prestidigitator has produced, as if from nowhere, another "convenience unknown" with which to bewilder our reasoning faculties. Is the "electricity of the medium" a new entity distinct from the ether? If so, is it a fluid, is it of a material nature, is it force, energy, spirit, demon, or just an ordinary scientific term? Whatever it is, how does it attach itself to, and operate in or upon, the medium? Does it affect or change the medium in any manner whatsoever; and if so, in what manner? This electricity, this something, is assumed to be so related to the medium that

it can be displaced toward the action at a distance effect. At this point in the argument the scientific magician produces from his resourceful sleeve another entity to which he gives the name "action at a distance effect." An "effect" ordinarily means a result or consequence manifest in a change of state or condition of things. Therefore, in the generally accepted meaning of the term, an effect certainly is not a thing. However, if an effect is not a thing, how can we comprehend the supposed displacement of the electricity of the medium toward this effect? Moreover, this "thing effect" must have a definite spatial position, otherwise how can we understand the displacement of another something "toward" it? Furthermore, the "electricity of the medium" must itself be a thing if human intelligence is requested even to imagine its displacement. Assuming, then, that electricity is a thing, how and by what agency is it propelled through the ether? Does it pass over the ether particles as a ring may pass along a wire? Does it force the ether particles to open a free path for it along the line of its motion? What determines the direction of the motion? When it reaches its goal the "thing effect," how does it neutralize to a great extent this "thing effect"? Does a battle ensue between the "thing effect" and electricity, after which, and when the smoke has cleared, we look in vain for the greater portion of the "thing effect"? Does the greater portion of the "thing effect" go up in smoke? In the face of all these unanswered questions, we are confronted by the statement that the pressure which the medium exerts on account of the attraction of its internal electrifications tends to draw the bodies together. A moment ago we beheld the spectacle of the electricity of the medium being displaced toward the action at a distance effect. Now we find the electrifications performing another rôle entirely. The internal electricities are now acting like so many affinities under the spell of each other's mutual attraction. We infer that we are requested to complete the picture by conceiving the next tableau as revealing the electricities in closer proximity to each other. As a consequence of this action of the electricities, we are told that a "pressure" arises in the medium. "Pressure"? Is that a new term, or is it a condition? Is it intended by this new term that we

shall conceive a condition of "compression" as arising in the medium? Shall we think of the ether particles as being urged into a smaller space by the similar behavior of the electricities? How shall we reconcile this with the incompressibility of the ether? Will a vacuum arise in the rear and front of the compression zone? If so, what about the ether as an all-pervading continuum? If extraneous ether particles rush in to fill the gap, what real significance can then be assigned to the phenomena of compression? The two bodies *A* and *B* in this latter event will have no inducement to motion. If this mere phenomenon of compression is a sufficient inducement to such motion, how can the bodies move with these extraneous particles of ether in their path of progress? If a vacuum is produced in the rear and front of the compression zone, how is the fact that a state of compression exists in this zone to be made known across a vacuum? Assuming that the opposite electrifications are displaced toward the action at a distance effect whose nativity seems to be the bodies *A* and *B*, and supposing that these opposite electrifications are things, is it not then reasonable to suppose that *A* and *B* will be moved farther apart? The fact is that with opposite electricities upon *A* and *B*, the bodies tend to approach each other.

Despite all these pertinent and unanswered inquiries, the ether advocate shows his persistent bias for his favorite creature by charging us with a total misunderstanding of the wonderful real relation which exists between ether and matter. We are consequently informed most emphatically that the ether permeates matter as water does a sponge—only more so, of course. Moreover, we are instructed to conceive the body *A* as a hollow ring, whether the poor thing *A* can obey this mandate or not; similarly our omnipotent intellect transforms body *B* into a ring with its inevitable hollow. Now intellectually mold the ether into a cylinder of suitable size to allow the rings *A* and *B* to be passed over it. Then when compression sets in within the ether cylinder the bodies *A* and *B* simply must move toward each other. Something must happen, and the two bodies *A* and *B* certainly are not going to upset all respectable traditions and move away from each other. If the bodies *A* and *B* are to be affected at all by the state of compression in the ether cyl-

der, a definite causal interaction between the cylinder and the two bodies must be clearly established.

The mere fact that the two material rings *A* and *B* are so arranged upon the cylinder that they can slide upon it is not a sufficient reason for the assumption that such a sliding motion will be initiated. Moreover, an axial contraction or expansion of the cylinder is not a sufficient cause for a displacement of the bodies. It is readily seen that the cylindrical model can be sufficiently modified to fulfil the requirements imposed by those who emphasize the peculiar importance of the alleged ability of the ether to permeate and invade all intra-molecular spaces. Such an extension of the idea in no way affects the crucial point in the argument, which pertains to the omission of that fundamental relation of rapport which must exist between the ether cylinder, no matter how complex the model is made, and matter, if the latter is to be cognizant of any modifications within the ether. Even the entire removal of the ether section between *A* and *B* cannot disturb the peaceful slumbers of these two material bodies.

HYPOTHESIS II

First Factor. Action at a distance considered as non-existent.

Second Factor. Entire effect regarded as existing in the ether.

Assumptions

In Cases I and II of the first hypothesis, the nature of polarization, represented in the space between bodies *A* and *B* in Figures 1 and 2, depends upon the interpretation placed upon the term "electricity."

In the second hypothesis the symbolic, graphical representation is intended to define the nature of an electric charge by means of the state of polarization in the medium. The particles of the dielectric are considered as charged with opposite electricities. No action at a distance factor is depicted upon bodies *A* and *B*. The phenomenon is supposed to be due entirely to the activities of the medium. In a space *C* devoid of the medium neither forces nor polarization

are considered to exist. The relations are shown graphically in Figure 3. This conception of the ether is due principally

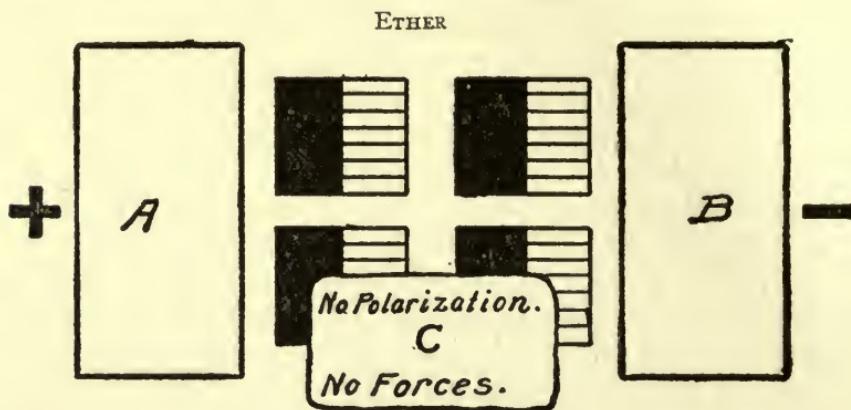


Figure 3

to Clerk-Maxwell, who desired to avoid distance forces completely.

Implications

The bodies *A* and *B* are regarded as contributing nothing to the electric disturbance observed. If a change of state in the system is observed, we have at least the right to ask for a physical antecedent in the event that the term "cause" is deemed objectionable. Since bodies *A* and *B* are not included in the series as factors influencing a change of state in the system, it can make no difference in the condition of the system if a charge exists upon the bodies, or if the notion of a charge is entirely eliminated from consideration. The fundamental assumption is that the conditions existing in the ether are independent of the states existing upon the bodies *A* and *B*. Nevertheless, observable physical phenomena always involve material aggregates, in the absence of which physical manifestations become impossible for observation. It is the very presence of a charged body that constitutes the physical antecedent of any change in condition or state which may be assumed to originate in the intervening or surrounding space. Without the existence of this charged body, the entire phenomenon becomes nothing but a dream of an over-ardent mathematician. If the charged body does not exist or perform some modifying function in the system, the ether space must remain a blank.

The introduction of a charged body into the system, nevertheless, is known to produce a change of state in the system. This change of state may not be a new condition in the ether, but it is a genuine modification of some sort, because actual observations testify to such a change. Consequently if the ether is to have any more real significance than empty space, we must assume that the condition existing upon the charged body is in some manner transmitted to the ether. The advocates of this latter hypothesis, no doubt, find considerable solace in the fact that the ether is assumed to be so intimately interwoven with, or contiguous to, the material aggregate that no empty spaces intervene to frustrate or hinder action or transmitted action in the system. The modern physicist fears empty space as persistently as a mouse fears a cat. Spatial contact is the "open sesame" of science. Through the magic of this relation science hopes to give plausibility to many of its hypotheses. Close scrutiny of the notion reveals the injection into it of an activity principle of a causal nature, capable of producing real changes and modifications in relations previously existing. Spatial contact becomes an activity factor in the system. It brings about the transmission of an influence from a group *a* to another physical group *b*. Without spatial contact, the scientist believes the transmission to be impossible. Consequently, contact is the factor which initiates the phenomenon of transmission. Therefore it must be regarded as an activity factor even if this inference is objectionable to science. Nevertheless, it is just as difficult to understand how an influence can be transmitted from *a* to *b* if spatial contact obtains as it is to conceive this transmission if a vacuum intervenes. If group *a* is alien to group *b*, spatial contact during eons of time will not cause or produce a change in the relation of *a* to *b*. Spatial contact is merely an incident of physical interaction. It may be an inevitable incident, nevertheless it is not an active factor in the interaction. It "does nothing," but it is a visible relation brought about when some actual change has taken place in the system. The idea of action at a distance is, therefore, just as conceivable as transmitted action by means of spatial contact. Neither of these notions is tenable unless we modify our entire conception of physical action. This part of our

discussion will be considered in more detail hereafter. For the present we must content ourselves with the statement, which will be more fully proved later in the discussion, that spatial contact is not an adequate bridge between matter and ether. It is evident that this statement obtains also for matter aggregates. If a charge exists upon a body, then mere spatial contact with the ether will not cause the medium to become cognizant of this fact. Moreover, we maintain that the condition of the body is a factor which cannot be ignored in a consistent interpretation of subsequent events. The attempt of Maxwell to avoid the difficulties of the action at a distance hypothesis has only resulted in new difficulties of just as serious nature. If the reader entertains any doubt that we have presented the modern ether hypothesis in a true and consistent manner, we refer him to the classic memoir of Heinrich Hertz.

54. Campbell's Criticism of the Ether.

In closing this portion of our critical analysis of the concepts of science, we shall quote the following from Norman R. Campbell's work "Modern Electrical Theory." "The dictionary may be searched in vain for a word which has given rise to more confusions and misunderstandings; the amazing pronouncements about the 'æther' which have been made by many philosophers are rivalled by the statements which are to be found in the writings of men of science of the highest repute. There seems to be a strange attractiveness about the word; a student never feels so important as when he is about to introduce it into his examination papers, it is to be found in monographs on the geometrical fourth dimension and in treatises on the more obscure issues of theology. . . . Because a name has been given to the conception of the 'æther,' it has been assumed straightway that the æther is a substance, separate from the material bodies of the system and moving independently of them: for no other reason than the existence of the name it has been assumed that this æther has mass, elasticity, even weight: qualities which are only known to be associated with material bodies have been attributed to it, one after the other, until Mendeleef suggested that it is a chemical element with a place in the periodic series."

55. McDougall's Mentiferous Ether.

It is indeed gratifying to note that Campbell advocates, in the above-cited work, the abandonment of the ether hypothesis. It is a regrettable fact, however, that Campbell, apparently, adopts the Thomsonian tube of force as a substitute for the ether which he abandons. In thus seizing another inexplicable convenience unknown, he forcibly illustrates how difficult it is for a man of science to arrive at a consistent philosophical conception of the universe. As a scientific talisman the ether, nevertheless, remains supreme in the annals of science.

It is a lamentable fact that Professor McDougall has added another ether to the mutitudinous clan. He calls his new "creation" the "mentiferous ether." It is the very latest thing in ethers. This mentiferous ether is a psychic ether and as such it is a revelation in ultra-fashionable ether styles. He gives "weight" to the concept by designating it as an imponderable substratum. The states of consciousness have always proved to be an irresponsible contingent, difficult to hold together. As a psychical glue, the manufacturer claims marvels for his mentiferous ether. Its adhesive properties are so wonderful that one state, through its use, readily recognizes another state and converses with it, in addition to the fact that it is forced to acknowledge itself as a dweller in the same spiritual soul house with other conscious states, all of which are owned by the same spiritual proprietor. The preceding considerations are sufficient to dispose of this latest scientific phantom.

56. Physical Action at a Distance. Coulomb's Hypothesis.

Having disposed of the tube of force and the ether as inconsistent and rationally impossible hypotheses, we shall now lend our attention to the analysis of the physical action at a distance phenomenon.

FIRST HYPOTHESIS COULOMB'S

Assumptions

If a body *A* (Fig 4) exists alone, then there is no action at a distance exerted. The appearance of force presupposes

the presence of at least two bodies (Fig. 5). The nature of this force may be one of attraction or repulsion, as indicated in Fig. 5. This view of action at a distance was entertained by Coulomb.

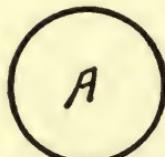
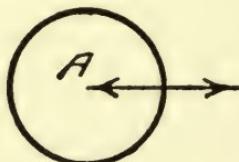


Figure 4



ATTRACTION OR REPULSION

Figure 5

It is not our intention to discuss the most vital difficulties involved in this or in the second hypothesis under this caption, for the reason that due consideration will be given to the matter later, when we analyze the problem of physical action in general. Here we merely wish to call attention to the principal views which have appeared in regard to distance action. The implications which we shall consider will be only those which are at once apparent.

Implications

It is clear that Coulomb's hypothesis involves a dualism of matter and force. The inherent difficulties of this position have been pointed out in part in the above. It is assumed that when the body *A* exists alone no action is exerted and force does not make itself manifest. The instant, however, that a second body *B* is introduced, then the force appears and the activity appears as either attraction or repulsion. It may be impertinent to ask whence does the force proceed to the bodies? How does it make its presence known? Does it subdivide itself in any particular manner; and, if so, what governs the relative amount of the subdivisions? Do the subdivisions attach themselves to the bodies *A* and *B*? What mechanism is used in effecting this attachment? How are the relative amounts that go to *A* and *B* determined? Shall we assume that the force exists not upon the bodies *A* and *B*, but between them? If the latter be true, how does the force make its desires effectively

felt in or on *A* and *B*? What determines the choice of attraction or repulsion as the final result of the interview between matter and force?

The enunciator of this hypothesis has not deviated from the customary course pursued by men of science, and consequently he has simply ignored these questions, if they ever occurred to him. All that seems necessary for the production of a scientific hypothesis of this kind is to write names like force, bodies, attractions, repulsions, and action at a distance upon pieces of paper, throw them together in a hat, and then you can observe the genesis of a scientific hypothesis. When we deal with the problem of physical action we shall point out difficulties which inhere in all these hypotheses.

SECOND HYPOTHESIS

Assumptions

This hypothesis supposes that every individual body sends out strivings throughout space. The single body *A*, shown

in Fig 6, radiates these hopes and desires in all directions into every imaginable point of space. The observer does not become cognizant of these longings of the body *A* until a second body *B* is introduced into the scenario. Then the action of the drama begins, and something happens to which mathematics can be applied.

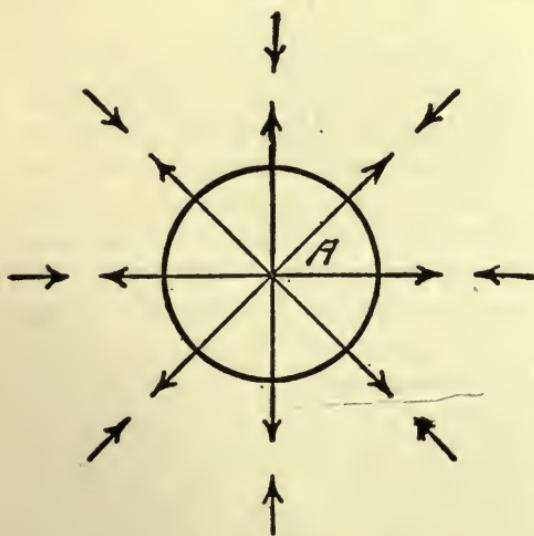


Figure 6

Implications

If things are regarded as independent and unrelated, then the assumptions of the second hypothesis are of no

avail in establishing action, whether the action be considered as taking place across a void or through a medium. If the strivings radiated by the body *A* are to produce an effect or a change in the condition of body *B*, then body *B* must, as it were, understand the language of body *A*. In the physical universe an "understanding" is impossible between bodies unless interaction in a unitary system is admitted. Moreover, a possible "understanding" is not conceivable in the physical world unless the cosmic relations are grounded in a Reality capable of creating a rational interacting unitary world order. The ordered responsive relations between things in this unitary cosmic system are due, then, to an omniscient act of God. The cosmic symphony is God's composition and its harmonious phrasing of interaction is due to His Divine Intelligence. The "understanding" between things is that God-given endowment which we perceive as those intelligible rational relations which we call the laws of nature's interaction.

57. Interaction According to Boscovich.

We believe that a broad interpretation of the views held by Father Boscovich, and enunciated by him in 1750, include interaction between his force centers regarded as a unitary system. Father Boscovich realized fully that action at a distance is involved in all physical phenomena. He showed profound insight in his unification of force and matter in the concept of the force center. His contention that these force centers exhibit their mutual dependence in mutual attractions and repulsions indicates that he realized the futility of the notion that the centers are independent. According to Boscovich the force center is endowed with inertia. We may think of the inertia as resistivity to a change in the condition of motion. Since a condition of absolute rest or zero motion is unknown in the physical universe, we provide in the Space-Time Potential for this resistivity in our gyration groups of force centers. The basic concepts of the Space-Time Potential are modern developments of the prophetic insight of Father Boscovich.

In the following we shall present the fundamental facts underlying physical action.

58. The Basic Elements of the Space-Time Potential.

The following principles constitute the fundamental truths which serve as the foundation upon which the purely physical assumptions rest:

1. The existence of God.
2. All reality owes its existence and maintenance to God.
3. The immanence of God throughout the universe, and also His transcendence.
4. The cosmos is a unitary, interacting, rational, purposive, and teleological system.

Auxiliary Principles

1. Matter is composed of cosmic activity centers manifest in space and time appearing in accordance with the law of causation. Matter owes its existence to a creative act of God.

2. Action at a distance is presupposed in all physical action.

3. Independent and distinct force entities do not exist apart from matter. Kaufmann's researches bear out this contention.

5. The continuance of cosmic activity involves the maintenance of an ultimate potential difference. God only is capable of maintaining this ultimate potential difference.

The cosmic energy owes its existence to a creative act of God. The maintenance of that ultimate potential difference which guarantees the continued operation of the cosmic machinery is due to the immanence of God, who is also transcendent. The Divine Intelligence is not only immanent in the universe, but His Being is also transcendent.

59. Fundamental Concepts.

In order to measure and record the magnitude of physical change it is necessary arbitrarily to differentiate phenomenal action into particularized groups. This involves the arbitrary separation of a given phenomenon into phases interpretable in terms of arbitrary concepts capable of mathematical representation. Unity is consequently differentiated into multiplicity, which has no significance other than an arbitrary and necessary convenience. These arbi-

trary conceptual artifices do not thereby achieve existence as independent physical realities. Therefore there ensues a complete relativity of those basic arbitrary concepts which constitute the alphabet of the language of science. This very relativity of meaning constitutes the closed chain of the conceptual edifice of science. This inherent relativity forces us to pass beyond the closed chain if we wish to arrive at a real understanding of physical phenomena. Within the closed chain no genuine explanation of physical change is possible. Every explanation within the closed chain is merely relative. One fragmentary action is explained in terms of some other fragmentary action. One concept involves another, and so on for ever and ever around the circle of concepts. No single concept is independently defined. By remaining within the closed conceptual chain we cannot arrive at an independent principle capable of explaining physical phenomena. Thus we are forced outside of the closed chain to the concept of God as the only concept which can account for physical action.

The complete relativity is another proof of the completeness of the world within itself. It is a proof that the world is a unitary interacting system. It is a proof that the world is a created completeness created by a Being distinct from any form observed within the system. The entire structure of science, therefore, becomes a proof of the existence of God the Creator. Science would not be possible without concepts, but a colossal error is committed when science ascribes more than relative significance to these concepts. Science extracts and isolates concepts from a unitary reality; then these mere products of thought are endowed by science with physical reality. A physical model constructed from such concepts must always remain inoperative; the parts of the machinery may be properly designed, but the motive power is missing. A pure mechanistic theory of the universe is impossible.

The Space-Time Potential interprets the physical world by means of *relative concepts*. Its physical model is merely a tentative design devised for the sole purpose of rendering the cosmic machine more intelligible and assisting in the further and more perfect elaboration of the design. The source of the primal motion of the cosmic machine cannot

be found in any of its members nor in any of its relative concepts. No physical machine is operated by self-generated power. Stevinus, in his work "Hypomnemata Mathematica" (1605), proved by means of a closed chain and the inclined plane over which it was suspended that perpetual motion is impossible. The cosmic machine is no exception to this scientific proof. Scientists would like well enough to make just one exception in favor of the cosmic machine. Such an exception would make all their work of no value. Consequently primal motion is due to an agency outside of the cosmic machine. Since the relativity of this agency pertains to the whole cosmic machine and is not involved as a part thereof, such an agency is efficacious in originating primal motion. The concept of God satisfies this demand.

60. The Relative Physical Concepts of the Space-Time Potential.

The relative physical concepts of the Space-Time Potential contain no activity principle capable of accounting for physical phenomena. This activity principle is found in the existence of God. The relative concepts are epitomized relative phases of genuine physical action. They are only of relative value in describing phases of phenomenal action whose ultimate significance cannot be defined in physical terms.

61. General Relativities.

Matter and Action

Matter is known only through physical action.
Physical action always involves matter.

Action and Reaction

To every action there is opposed an equal reaction.

Consequently every physical action involves two material systems:

1. The Excitant System.
2. The Concurrent System.

The *Excitant System* is that system which we arbitrarily select as the initiatory system in the causal nexus. The *Concurrent System* is that system which responds to the

initiatory system in accordance with the law of equality between action and reaction. Both systems are material systems. The Concurrent Material System may in certain class phenomena play the part of a medium. The Concurrent System, when regarded as a medium, does not thereby become an Ether, because the Ether is not a material system. On the contrary, the Concurrent System, being matter, possesses all the properties of matter, and its content contains none of the inconsistencies of an ultra-material ether.

Motion

The concept of motion involves:

1. A center or body which moves.
2. Another center or body in respect to which it moves.
3. A distance traversed.
4. A time interval consumed in the displacement.

Motion may be described as being:

1. Rectilinear.
2. Curvilinear.
3. Combinational, involving rectilinear and curvilinear displacement.

62. Primary Relativity Concepts.

Action Phase

Physical action always means interaction. The systems involved in interaction exhibit interdependent physical changes. For the purpose of analysis we arbitrarily differentiate physical change or action into such convenient conceptual types as mass, velocity, acceleration, force, torque, kinetic reaction, impulse, work, energy, electric charge, attraction, repulsion, equilibrium, etc. To these conceptual types of physical change we give the name *action phases*. The actual physical change involves many action phases. Action, then, is a continuous characteristic physical unity which involves a multiplicity of action phases. These action phases have no independent reality. They are not independent physical entities. The action phases are convenient analytical segregations from a reality whose existence in-

volves more than the sum total of these thought segregations.

Physical Measurement

All physical measurement is relative.

Mass Phase

Mass phase is one of many action phases pertaining to matter. Formerly mass was considered to be that property of matter which served best to represent a body in the investigation of its motion because it was intimately connected with motion, and also for the reason that it remained a constant throughout motion. For ultra-atomic particles this is no longer true except within well-defined limits. For bodies, however, the relation holds. The relativity of mass was established by Kaufmann, who showed that the mass of the electron varies with the variation in velocity. Ultimate matter is, therefore, not a fixed, unchanging something. We must readjust our notion of mass and think of it as a phase of *kinetic matter*. From this new viewpoint we define mass phase as follows:

Mass phase is that segregated action phase of kinetic matter which lends continuity to physical change.

Measurement of Mass Phase

Let F_1 and F_2 be the *force phases* involved in the interaction of two bodies exhibiting the respective mass phases M_1 and M_2 , and let a_1 and a_2 be the corresponding observed acceleration phases; then the following relations hold:

$$F_1 = M_1 \cdot a_1,$$

$$F_2 = M_2 \cdot a_2,$$

$$\frac{M_1}{M_2} = \frac{F_1}{F_2} \cdot \frac{a_2}{a_1}.$$

The latter expression points to two methods of relatively measuring mass phases; the first method being relative to the force phases, while the second method depends for its relativity upon the acceleration phases.

METHOD I. FORCE PHASES USED AS THE RELATIVE
MEASURE OF MASS PHASES

It is evident that if $a_1 = a_2$, then the expression

$$\frac{M_1}{M_2} = \frac{F_1}{F_2} \cdot \frac{a_2}{a_1} \quad \text{becomes}$$

$$\frac{M_1}{M_2} = \frac{F_1}{F_2}.$$

This is the case when the two bodies are subjected to the common acceleration g due to gravity. In that case the force phases F_1 and F_2 become the corresponding weight phases W_1 and W_2 and we have:

$$W_1 = M_1 \cdot g$$

$$W_2 = M_2 \cdot g, \quad \text{and consequently}$$

$$\frac{M_1}{M_2} = \frac{W_1}{W_2}.$$

It follows that we have a *relativity equation* between mass phases and force or weight phases. In other words, *the mass phases are proportional to the weight phases*. We have not achieved an *absolute measure* of the mass phase. The method is purely relative because the weight or force phase is not of the same conceptual order as the mass phase. Moreover, the fact that we have mathematically eliminated the common constant g does not involve the actual elimination of that physical activity relation upon which the acceleration g depends. We have therefore used the force phase to measure the relative magnitude of the mass phase.

METHOD II. ACCELERATION PHASES USED AS THE RELATIVE
MEASURE OF MASS PHASES

In the expression

$$\frac{M_1}{M_2} = \frac{F_1}{F_2} \cdot \frac{a_2}{a_1},$$

if we arrange conditions so that $F_1 = F_2$, then

$$\frac{M_1}{M_2} = \frac{a_2}{a_1}.$$

In this case the mass phases will be inversely proportional to the acceleration phases. This latter method is consequently *no more absolute* than the former. Hence the second method is merely a *relative measure* of the mass phase.

Mathematical Definition of Mass Phase

The mass phase M of a body is that relative phase magnitude which is commensurate with the quotient obtained by dividing the magnitude of the force phase F by the magnitude of the acceleration phase a . The truth of this definition is evident from the following relations:

$$F = M \cdot a = M \left(\frac{dv}{dt} \right), \text{ therefore}$$

$$M = \frac{F}{a} = \frac{F}{\left(\frac{dv}{dt} \right)}.$$

Measurement of the Magnitude of Motion. Velocity Phase

The velocity phase is a mathematical measure of motion. The velocity phase v involves both space and time in that it is defined as the quotient obtained by dividing the distance s traversed by the center in the time period t consumed in the displacement. For a constant velocity the requirement is that the distance traversed in equal intervals of time, however small these time intervals may be, shall be equal. The general expression for velocity phase v is

$$v = \frac{s}{t} = \frac{ds}{dt}.$$

The term *speed* is used to denote velocity irrespective of direction. Motion generally involves both changes in velocity and direction, hence the following general definition of velocity phase.

The velocity phase of a center in any point of its path is the quotient obtained by dividing the immediately adjoining distance traversed by the time period of the center whose direction is regarded as the instantaneous tangent to the curve of its path of motion. Velocity phase is purely relative and involves an arbitrary reference point or reference system.

Acceleration Phase

The acceleration phase is a mathematical measure of the change of the rate of motion. Like the velocity phase, it involves space and time and is always a relative measure. It involves a change in the velocity phase. The change in the velocity may involve an increase or a decrease (positive or negative acceleration), it may involve a change in the direction of the motion, and it may involve a change in the velocity as well as in the direction.

This may be stated mathematically by letting v_1 and v_2 be the respective velocities at the beginning and the end of a time period t , then the acceleration a is given by the relation

$$a = \frac{v_2 - v_1}{t}.$$

The general definition of *acceleration* may be formulated as follows: The acceleration phase of a center in any point of its path is the quotient obtained by dividing the difference in the velocities dv accruing during an infinitesimally short period of time dt by this time period dt . The path traversed is considered of infinitesimal length. The expression

$$a = \frac{v_2 - v_1}{t} =$$

average acceleration or rate of change of velocity. When the distance traversed becomes infinitesimally short then $(v_2 - v_1)$ becomes dv , and t becomes dt , and the general definition, stated mathematically, becomes

$$a = \frac{dv}{dt}.$$

Force Phase

Force phase is that segregated action phase of kinetic matter which qualifies the magnitude of the intensity of the real interaction between kinetic matter groups. The actual physical change is not brought about by independent force entities. There are no independent force entities. The intensity of the interaction, however, may be relatively measured in terms of force phases.

Mathematical Definition of Force Phase

The force phase F is that relative phase magnitude which is commensurate with the product of the mass phase M and the acceleration phase a , hence

$$F = M \cdot a = M \left(\frac{dv}{dt} \right).$$

Kinetic Reaction Phase

From the general law of action and reaction we know that to every action there is opposed an equal reaction. Consequently the sum of the action and the reaction exhibited in a physical change is equal to zero. Now if we think of action as exhibiting a force phase and reaction as exhibiting a kinetic reaction phase, then we may state the general law as follows:

The sum of all the force phases exhibited in a physical change plus the kinetic reaction phase equals zero. Stating this mathematically, we have: Sum of all the force phases + the kinetic reaction phase = 0; or

$$M.a. + \text{Kinetic reaction phase} = 0; \text{ hence}$$

$$M.a. = -\text{Kinetic reaction phase} = -M.a. = -F.$$

The general expression will involve a constant of proportionality C . This constant C , however, becomes unity when the quantities involved in the expression are measured in terms of the same units. The negative sign indicates that the kinetic reaction phase R is opposed to the force phase F .

Mathematical Definition of Kinetic Reaction Phase

The kinetic reaction phase R is that relative phase magnitude which is commensurate with the product of the mass phase M and the acceleration phase a . It is equal in magnitude, but opposed to the force phase F . Consequently,

$$R = -F = -M \cdot a = -M \left(\frac{dv}{dt} \right).$$

The Three Cosmic Fundamentals

The conceptual structure of the physical universe is built upon the three fundamentals, space, time, and interaction. The last, i. e., interaction, involves rational causation with its inevitable accompaniment of natural laws. The causa-

tion is both primary and secondary. The interaction in the physical universe involves a manifold of secondary causes. Since the system is complete within itself, these secondary causes are as completely relative as all the relativity concepts. No secondary causation within the system can account for its initial and maintained interaction. The unitary relativity system owes its existence to the Being of God. The three cosmic fundamentals consequently are space, time, and potential.

The physical tapestry of the universe is a web woven from the woof of potential and the warp of those forms of apprehension which we call space and time. The primary relativity concepts are built upon these three cosmic fundamentals.

63. Secondary Relativity Concepts.

The secondary relativity concepts are built up from combinations of the primary relativity concepts. Consequently they also involve the three cosmic fundamentals as their basic constituents. Two principal conceptual combinations may be made from the force phase and the two forms of apprehension, space and time.

I. THE FORCE PHASE COUPLED WITH THE TIME FORM

When interaction exhibits a displacement of a center or body, then the action intensity may be considered as commensurate with the product of the force phase and the time interval involved in the change.

Mathematical Definition of Impulse Phase

If the force phase is constant both in magnitude and direction, then the impulse phase I is commensurate with the product of the force phase F and the time interval t of the change. Consequently we have the expression:

$$I = F \cdot t$$

Now if the force phase varies in magnitude and direction, then we must add, by the calculus, the impulse phase

dI exhibited in infinitesimal intervals of time dt . Therefore the expression becomes

$$dI = F \cdot dt, \quad \text{and}$$

$$I = \int_0^t F \cdot dt$$

II. THE FORCE PHASE COUPLED WITH THE SPACE FORM

When interaction exhibits a displacement of a center or body, then the action intensity may be considered as commensurate with the product of the force phase and the displacement distance.

Mathematical Definition of Work Phase

If the force phase is constant both in magnitude and direction, then the work phase W is commensurate with the product of the force phase F and the distance s of displacement. Therefore we can write the following expression:

$$W = F \cdot s$$

If the force phase varies in magnitude and direction, then we must add, by the calculus, the work phases dW exhibited in infinitesimal distances ds . Therefore the following expression obtains:

$$dW = F \cdot ds, \quad \text{and}$$

$$W = \int_0^s F \cdot ds$$

Mathematical Definition of Energy Phase

Energy phase and *work phase* are correlative concepts. The energy phase E is commensurate with the work phase W , which is developed during a change from an actual condition to a standard condition. The inverse process involves the same work phase magnitude. Consequently the energy phase E may be regarded as commensurate with the work phase W which must be expended in bringing about a change from a standard condition to an actual condition. Herein we clearly see the *ascending* and the *descending* processes involved in a change from a condition A to a condition B . The energy phase, or the work phase involved, in passing either from condition A to condition B , or from

condition *B* to condition *A*, is in either case of the same magnitude.

The manifesting energy phase which is concomitant with motion is called *kinetic energy*, while the available work phase due to position is termed *potential energy*. An available work phase is commensurate with a potential energy phase, while a developing or unfolding work phase is commensurate with the kinetic energy phase. Ultimately the various forms of energy phases are, in the last analysis, of a kinetic nature. If we regard the matter from the standpoint of action and reaction, then the kinetic energy phase *E* is commensurate with the work phase *W* involved in the production of a velocity phase *v* against the interacting kinetic reaction phase *R*. Stated mathematically this relation takes the form

$$E = -W = - \int_0^s R \cdot ds = - \int_0^s (-F) ds = - \int_0^s \left\{ -M \left(\frac{dv}{ds} \right) \right\} ds;$$

since

$$v = \frac{ds}{dt}, \quad ds = v \cdot dt, \text{ and}$$

$$E = - \int_0^s \left\{ -M \left(\frac{dv}{dt} \right) \right\} v \cdot dt = M \int_0^s v \cdot dv = \frac{1}{2} M v^2 - \frac{1}{2} M v_0^2.$$

In the above the first negative sign signifies that an energy phase *E* is developing as a work phase *W* against the kinetic reaction phase *R*. The negative sign preceding the term *F.ds* indicates that the force phase appears as a kinetic reaction phase.

The last of the above expressions,

$$\text{i. e., } \frac{1}{2} M v^2 - \frac{1}{2} M v_0^2,$$

represents the change in the kinetic energy phase which is concomitant with that work phase which is involved in the change of the velocity from v_0 to v .

The relativity concepts defined above constitute the basic concepts from which all other necessary concepts may be derived. They have been defined as phases of interaction having no independent existence. In the following portions of the work the word "phase" has been omitted for the sake of brevity. We wish to emphasize the fact that

this omission in no way alters the intent of the definition given above. The relativity concepts are the mathematical descriptions of arbitrarily chosen fragments of phenomenal activity, and they do not even begin to exhaust the content and meaning of reality, which is known in its full intent only to God, its Creator.

Interaction in a Unitary System

Matter is that persistent phase of activity which appears continuously throughout change and becoming. Matter has persisted in its continuous and uninterrupted manifestation throughout the ages. This persistence in the past constitutes our only basis for the assumption of its continued manifestation in the future. We cannot prove that this assumption is valid indefinitely. Ultimately the persistence depends upon teleology above finite consciousness, that is, upon the omniscience and omnipotence of God. Phenomenally, matter is differentiated into a multiplicity of interacting and related activity centers. We have given the name *monon* to these activity centers. Regarding them from their force phase standpoint, we think of them as force centers. Since the energy phase may be considered as more inclusive, we may think of them as centers of energy. These phases are not invariable. Their only constancy is persistency and continuity. This is true of the mass phase as well of all other action phases. Throughout a series of energy transformations in a given system there is no apparent evidence of a lose or gain of either mass, force, or energy, provided that we make the system sufficiently inclusive. This fact serves as the basis of the postulate of conservation. This persistency, which we call conservation, depends for its future continuation upon the life of God. Action phases do not exist as independent entities. Mass, force, and energy entities do not exist as independent existencies. Mass, force, and energy are phases of an activity which includes them and all other action phases. Modern scientific research bears out these contentions. The cosmos is a unitary interacting system in which the distance and duration are respectively the spatial and temporal indicators of the relative magnitude of the interaction between things.

CHAPTER IV

THE PROBLEM OF A PHYSICAL SUBSTRATUM

64. Physical Substratum.

CASE I. SUBSTRATUM DEVOID OF QUALITIES

Contemplation of the world of phenomena leads us to the two fundamental concepts, Being and Becoming. In the last stage of every analysis of the nature of the objects of perception we encounter some type of elementary particles which we name molecules, atoms, and electrons. Our question concerning the nature of an object finally resolves itself into the discovery of the kind of elements of which its material portion is made. It is a process of reducing complexity to simplicity.

Let us take for consideration the well-known substance water. At ordinary temperatures water is a liquid, at higher temperatures it is a vapor, and at lower temperatures it is a solid. What, then, is water when it is not influenced by temperature or other conditions? You will undoubtedly answer this question by saying that water is an existent something which under one condition reveals itself to sense as something *A*, while it appears as something *B* under another condition, and under a third condition it exhibits itself as something *C*. Experience has taught us that a second assumption is within the realm of the highly probable. This is the assumption that a reversal of the order of the conditions produces a reversal in the appearance of the states from the sequence *A, B, C*, to *C, B, A*, without the anomalous appearance of an alien state *M* totally foreign to the substance water. A thing, then, is what it is on account of the regularity of its changes within a given series. Independent of the assumed forms within the series, a thing has no existence independent of these forms. However, you will maintain that the crux of the matter lies in the fact that this independent existence is the basic sub-

stratum about which states and forms drape themselves. You believe that the existent is truly represented schematically in Figure 7, where a real substratum *A* is vitally associated

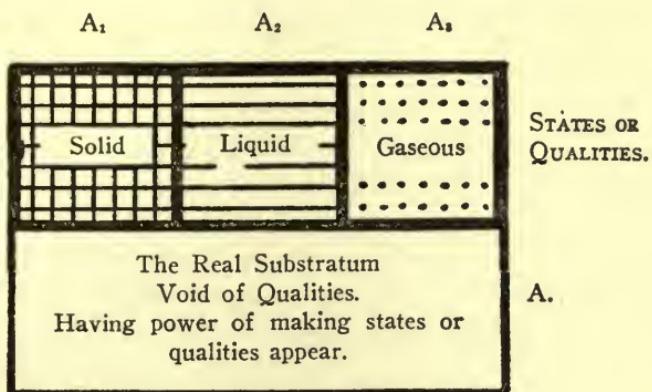


Figure 7

ated with the states *A*₁, *A*₂, and *A*₃, which are its individual and personal property. Your contention, then, is that the real substratum *A* is the abiding essence of a thing, and that the *A* is the subject which is potent to give reality to the changing qualities and states which it owns in a manner analogous to the varying states of consciousness which you own as an individual ego. These arguments remind us of Berkeley's presentation in the "Principles of Human Knowledge," from which we quote the following:

"But, say you, though it be granted that there is no thoughtless support of extension, and the other qualities or accidents which we perceive: yet there may, perhaps, be some inert unperceiving substance, or substratum of some other qualities, as incomprehensible to us as colours are to a man born blind, because we have not a sense adapted to them. But if we had a new sense, we should possibly no more doubt of their existence, than a blind man made to see does of the existence of light and colours. I answer, first, if what you mean by the word matter be only the unknown support of unknown qualities, it is no matter whether there is such a thing or not, since it no way concerns us: and I do not see the advantage there is in disputing about we know not what, and we know not why."¹

¹ Principles of Human Knowledge, Part I, lxxvii.

In the final analysis, then, you reduce substratum to a material of reality. It is neither this nor that, but a real, pure, and simple basis of this and that. In short, it is naught but the principle of reality.

Objection to Case I

How can an indeterminate, independent, and empty substratum *A* show preference at any one time for *a₁* as against *a₂* or *a₃*? By a process of successive negation, the "unknown support" of states and qualities, the ultimate material essence or substratum is reduced to an empty void. Let us quote again from Berkeley, in the Second Dialogue between Philonous and Hylas:

"*Phil.* Continue, good Hylas, to act the same ingenuous part, and tell me sincerely whether you can frame a distinct idea of entity in general, prescinded from and exclusive of all thinking and corporeal beings, all particular things whatsoever.

"*Hyl.* Hold, let me think a little. I profess, Philonous, I do not find that I can. At first glance me thought I had some dilute and airy notion of pure entity in abstract; but upon closer attention it hath quite vanished out of sight. The more I think on it, the more am I confirmed in my prudent resolution of giving none but negative answers, and not pretending to the least degree of any positive knowledge or conception of matter, its where, its how, its entity, or anything belonging to it.

"*Phil.* When, therefore, you speak of the existence of matter, you have not any notion in your mind.

"*Hyl.* None at all.

"*Phil.* Pray tell me if the case stands not thus: at first, from a belief of material substance you would have it that the immediate objects existed without the mind; then that their archetypes; then causes; next instruments; then occasions; lastly, something in general, which being interpreted proves nothing. So matter comes to nothing. What think you, Hylas? Is not this a fair summary of your whole proceeding?"¹

¹ The Second Dialogue, pp. 257, 258.

65. Physical Substratum.

CASE II. SUBSTRATUM ASSUMED TO POSSESS POWER OF SELECTION AND ATTRACTION

We present this case schematically in Fig. 8. The adherents to this view think of the states and qualities as independent entities. They assign to the real substratum two

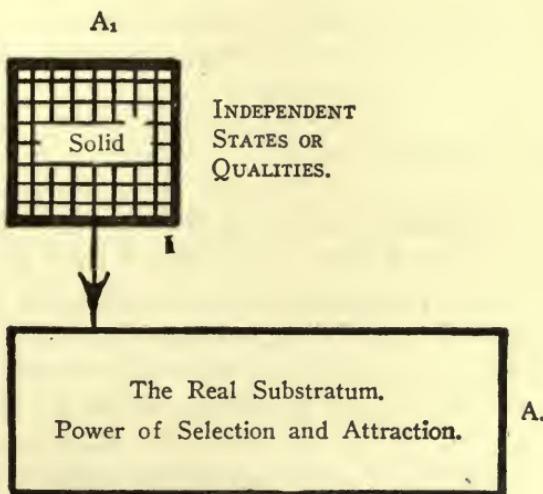


Figure 8

fundamental properties of selection and attraction by which the substratum A takes unto itself a particular state, for instance, the solid state a_1 shown in the scheme of Fig. 8.

Objections to Case II

First. How shall we explain the mechanism by which the real A selects, attracts, and incorporates with itself the state a_1 , in preference to another state b_1 , from another series of states or qualities?

Second. As far as phenomena are concerned, independent states and qualities give us all we need. A hypothetical substratum merely complicates the issue without in any way explaining the effects observed by the senses.

In trying to create this independent substratum in a world beyond states and qualities we commit the same error as the person who ascribes the color of a body to the body

beneath the pigment which was applied to produce the particular color. The pigment does not communicate its color to the entire substance beneath it. The body does not select nor attract a particular pigment in preference to any other. We are forced to the conclusion that the quality of color is a part of the nature of the pigment and not of the body beneath it. You will retort that we are begging the question because it is the substratum of the pigment which is responsible for its color. We reply that the process by which the pigment selects from the cosmic warehouse a preferred color is inconceivable, and we reiterate that our objections are valid.

66. Physical Substratum.

CASE III. FIXEDNESS GIVEN TO STATES AND QUALITIES BY INJECTION OF A GRAIN OF REALITY INTO A THING

The desire to give permanence and fixedness to the states and qualities of a thing is the root of a notion, held by many, that a portion of the stuff of reality is injected into a thing (see Fig. 9). This stuff of reality is the common basis or

property of things, and when qualities and states are grouped about it we have objects and things of the phenomenal world. In this stuff of reality we have something akin to the noumenon, or thing-in-itself, of Kant. Of the thing-in-itself Kant says: "We know only experiences, but not things-in-themselves." Nevertheless, Kant himself regards the thing-in-itself as the cause of phenomena in regard to both their form and matter. In this respect Kant involves himself in a serious

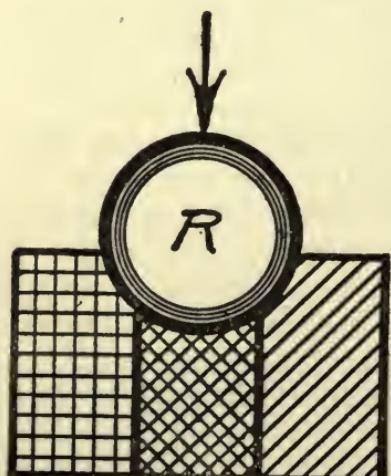


Figure 9

self-contradiction, for in so far as he has limited the concept of causality to experience, the realm wherein the thing-in-itself is unknown, how, then, can the thing-in-itself

be the cause of phenomena? Schopenhauer believed that he unveiled the thing-in-itself in his emphasis of the will as the primary phenomenon, that which constitutes the very basic essence of our real nature. However, since all we know of volition is phenomenal, Schopenhauer's principle of sufficient reason, which applies to phenomena, leaves the thing-in-itself undiscovered. We quote the following from Schopenhauer : "That what Kant opposed as thing-in-itself to mere phenomenon—called more decidedly by me *representation*—and what he held to be absolutely unknowable, that this thing-in-itself, this substratum of all phenomena, and therefore of the whole of Nature, is nothing but what we know directly and intimately, and find within ourselves as *the will*."

"The general meaning of the Principle of Sufficient Reason may, in the main, be brought back to us: that everything existing, no matter when or where, exists by *reason of something else*. Now, the Principle of Sufficient Reason is nevertheless *a priori* in all its forms: that is, it has its root in our intellect, therefore it must not be applied to the totality of existent things, the Universe, including that intellect in which it presents itself. For a world like this, which presents itself in virtue of *a priori* forms, is just on that account mere phenomenon: consequently, that which holds good with reference to it as the result of these forms, cannot be applied to the world itself, *i.e.*, to the thing-in-itself, representing itself in that world."

We see, then, that both Kant and Schopenhauer, in their sharp distinction between noumenon and phenomenon, inject into the world an antithesis, indefensible because the distinction, a mere product of the intellect, lacks confirmation in the groundwork of reality.

Objections to Case III

The error lies in postulating two separate and distinct entities in the groundwork of reality: first, a thing, and second, its content; first, a substratum, and second, its qualities and states; first, a thing-in-itself, and second, phenomena. A grain of the real can no more convey reality to the diverse qualities associated with it than a pigment can convey its coloring to an object. It is futile to expect that a sub-

stratum void of any content whatsoever can produce from its fatuous depths real states and qualities. Things are not real because of the presence of a real in them. Things do not become real because a real is injected into them, but they are real because they are capable of displaying, and actually do display, that type of activity which we term *reality*.

67. Identity of the Real with the States and Qualities.

CASE IV. THE HYPOTHESIS OF INTERACTION

We show this case schematically in Fig. 10. The difficulties involved in the previous cases are due to a search

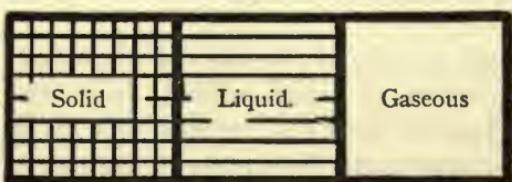


Figure 10

for the thing-in-itself beyond itself, to the separation in thought of thing and content. By admitting that a thing and its content are one, that qualities,

states, and substratum are inseparable real unities, we avoid the difficulty. This is the fundamental tenet of the hypothesis of interaction which we adopt as the only solution of the problems reviewed above. We have referred to the persistence of the sequence in change. The change series *A, B, C* can be and is reversed by a reversal of the antecedent conditions. This permanence in the order of change constitutes the so-called laws of action of things. We cannot separate these laws from things with any more justice than we can think into the real a substratum beyond the real. Laws are not entities disparate from things; they are not external powers which influence from without the sequence in the activity of things. The separation of law and thing is the work of thought. The real knows no such separation. When the eternally real expresses its own nature, then thought, finding permanence in this ever changing thing, describes the persistence in the mode of behavior of things by postulating laws which hold dominion over the action of things. It is just as impossible to conceive and arrange an effective and operative understanding between laws and things regarded as separate entities as it is similarly to connect substratum and states considered as independent exist-

ences. In this more complete view of activity we therefore maintain the identity of content, law, and thing.

Change or becoming, exemplified in birth and death, in origination and decay, is the content of all perceptual knowledge. As Heraclitus, the Greek philosopher, pointed out, the phenomenal world is in a constant state of flux or becoming. The concept of being, opposed to that of becoming, owes its origin to the hope of finding persistence and permanency in change or becoming. Observed phenomena tell a different legend to us than can be consistently brought forth by maintaining that an empty and void substratum is an effective basis of things. Things are, not by virtue of a substratum or ultimate substance in them, but they are, because their very nature makes it possible for them to convey to us the notion of persistence and permanence. This stability and permanence in things gave rise to the notion of a rigid, immutable nucleus or substance as the basic root of things. The prevalent notion of becoming or change is that the new real is merely a continuation of a previous real. The concept of a coming into or origination of a new real involves the notion that reality arises from a total absence of the real. Many superficial subterfuges have been resorted to in order to avoid this implication.

It is true that the old real does not contain within itself the reality of the new. The old reality must be disposed of before the advent of the new real. A reality A will never cease to be identically equal to A until it ceases to exist. To originate and to pass away is a continuous process during which we can say that origination equals origination and passing away equals passing away. In other words, $A = A$ only while A endures precisely as it is. This is the only sense in which we can conceive the validity of the Law of Identity.

Should we demand the *indestructibility of things* as a consequence of the Law of Identity, we must also demand the immutability of all states, qualities, and relations which pertain to things. There would then be no phenomenal world. The notion of the continuation of the same real unchanged is not a valid one in view of the facts of the phenomenal world. Permanence, therefore, is to be found only in the sameness of the process of decay and becoming.

Change, then, is not a succession of self-contained, immutable reals *A*, *B*, *C* separated as entities distinct from each other. The reals *A*, *B*, *C* cannot exist during the most minute interval of time in a condition of rest. The realities *A*, *B*, and *C* cannot at any stage of the phenomenon of becoming be regarded as stationary independent beings. Every form of the real must mean that the phase *A* is as truly in continuous motion as any other phase of *B* or *C*. Moreover, the direction in which becoming advances, the particular sequence in which change takes place, must be inherent in the very nature of the thing to which reality is assigned. Laws external to reality are both superfluous and inoperative. Being, then, is not a passive, inert something, but it is energy continuous in its manifestation, activity permanent as the basic function of things. Continuous life and activity is what constitutes reality.

These conclusions may remind you of the fundamental principles of Spinoza's philosophy. Far from denying this, we admit that we are at one with him if you will do him the justice of seeking for the basic thought which forms the nucleus of his reasoning. The method, however, by which Spinoza attacked his problem inevitably led him into difficulties in the rational development of his system which obscured the great truths which he announced. Spinoza says: "I understand Substance (*substantia*) to be that which is in itself and is conceived through itself: I mean that the conception of which does not depend on the conception of another thing from which it must be formed. An attribute I understand to be that which the intellect perceives as constituting the essence of a substance." For Spinoza the end of all thought is found in the principle of uniformity of Nature. Substance and law are, for him, identical. Spinoza's method consists in deriving ultimate concepts by a process of elimination of the limitations imposed by the specific qualities observed in connection with the objects and things of the phenomenal world. A concept derived by this method, from which every semblance of the reality of phenomena has been ejected, is nothing save a name applied to an empty void denuded of content. Hegel justly criticized Spinoza's Absolute by saying that it is like unto the lion's den to which all tracks lead, and from which none

return. Spinoza creates a gulf between the world of reality and the world of phenomena, and his method is not able to provide a bridge over the chasm. In fact, no system which makes this distinction between appearance and reality can ever construct a rational connecting span between these worlds. His method prevents him from consistently and rationally reaching the ever more inclusive reality of the unitary interacting universe in which lesser realities find their life's consummation. Notwithstanding the shortcomings of his method, Spinoza realized—shall we say intuitively?—the unitary intimacy of substance, nature, and law, for he does point out that nature is the inherent energy, active and manifest in all that exists; it is "*natura naturans*," and not merely the sum of all that exists, "*natura naturata*."

Again we call attention to the fact that we do not agree with philosophers who, like Kant, separate reality into two distinct parts, *noumena* and *phenomena*. Reality is not a synthesis of two entities, a thing-in-itself and its phenomenal aspects. If reality is a synthesis of two distinct essences, then we must assign separate properties to each of the two types. This would force us to separate the manner of knowing and perceiving into two modes corresponding with the two types of entities. The procedure may involve us in the conclusion that one type of reality is unknowable and the other knowable. For this and other reasons previously stated we hold the view that the substratum states, qualities, and laws are not independent entities, but that a unitary and not a synthetic reality manifests its nature phenomenally to sense. In maintaining the identity of substratum and content it must not be inferred that we hold the non-existence of either. Reality is more than that which is given by sense perception. The reality of a thing proceeds from a source more potent than mere sense manifestation. The mere isolated and individual data furnished by sense perception do not exhaust the significance of reality. The soul is more than thought, which in its turn is more than a mere sense stimulation. Nevertheless, the soul is a unitary being. A thing pulsates and throbs with a reality greater than the mere kinetic content of the "now." Its potential content of the "then" indicates a reality sus-

tained and potentially assured, which appears as the contentless background of the content of the "now" and also as the potent generative background of the content of the "then." Thus, in thought, is substance sundered from its content because the present content does not exhaust the total reality of a thing. That phase of reality which assures continuity throughout change and relative permanence to individuality and discreteness constitutes the essence of substance. Far from being a mere product of thought, substance finds its significance in the very depths of reality. The permanence of which we speak points to the maintaining potentiality of God. Thus we are in accord with the intent of Scholasticism in its treatment of the relation between substance and the sensible accidents of forms, qualities, and states.

68. The Problem of Physical Action.

Thesis

If we assume the *independence* of *separate* and *distinct* things, actions, states or forces, then it is impossible to transfer from a thing *M* to another thing *N*, an influence *I*, whether this influence be a thing, action, state, or force.

We shall demonstrate the validity of this thesis under the three following cases:

69. CASE I (a). INFLUENCE I, A THING

This case and all allied cases may be reduced in such a manner that three things only are involved.

In Fig 11 we show the factors involved in Case I (a). We assume that *M*, *N*, and *I* are things. At first hand there

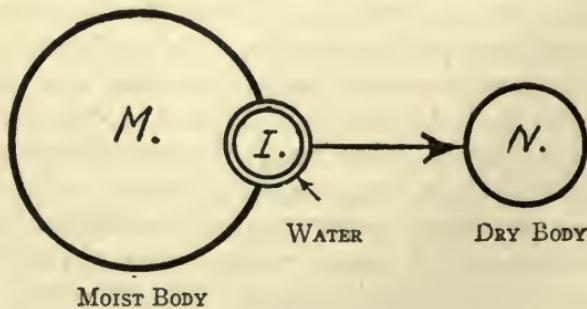


Figure 11

seems to be nothing difficult in the notion that the thing *I* can separate itself from *M* and pass to *N*, causing a change in the latter. Let us examine the case more closely. In order to make our problem definite we shall suppose that the body *M* is a moist body, meaning by this statement that there is moisture *I* in the form of water present in the body *M*. We shall also suppose that the body *N* is a dry body, meaning by this that no moisture in the form of water *I* is associated with the body *N*. If, then, we say that water *I* (being a real thing *I*) passes from the body *M* to the body *N*, and that when this transfer has been accomplished the body *M*, previously moist, becomes dry, while the body *N*, formerly dry, becomes moist, *we cannot then contend that either M or N has undergone any real change*. All that we can justly say is that the transfer of *I* from *M* to *N* has taken place. During the entire time, *M* remained *M* and *N* remained *N* and neither *M* nor *N* caused any modification in *I*. On this assumption our problem disappears, because what we wish to ascertain is how the influence *I* passing from *M* to *N* causes a genuine change in *M* and *N*. Actual facts do, however, bear us out in the assumption that a real change has been produced in *M* and *N*, for it is true that as *N* begins to get moist, due to the incorporation of *I*, the particles of *N* are forced farther apart and consequently occupy a greater space in addition to a further change which consists in a modification of the vigor of the connection between the particles of *N*. A reciprocal change occurs in *M*. Upon the withdrawal of the moisture *I*, the drying body decreases in volume, its particles attain closer proximity, and the vigor of the connection between them undergoes a change. The mere recording of the fact of transfer of *I* from *M* to *N* has not contributed anything to our knowledge concerning these real changes in both *M* and *N* which are simultaneous developments. It is our desire to comprehend these very real changes in *M* and *N*, and it is these modifications which constitute the gist of our problem. The only result accomplished is a new disposition of the seat of our problem. Our query takes a new and more definite form in that we now seek to comprehend how the presence of water *I* in *N* produces a change in *N*, and, moreover, how the withdrawal of *I* is a fact sufficiently potent to account

for the modification in *M*. Suppose we add to our little world another body *R*. This simple addition complicates the problem beyond measure. Now we are confronted with the problem of a choice, by the thing *I*, of its final destination. Will the thing *I* choose for its resting-place the body *R* in preference to the body *N*? If we maintain that the choice of *I* will be the body *N*, then such a statement will have no more significance than if we maintained that the choice must be the body *R*. Moreover, what is there involved in our suppositions which will cause *I* to come to rest in either *N* or *R*? Why not suppose, with equal show of justice, that the thing *I*, after parting company with *M*, avoids the bodies *N* and *R* and then tours the universe, without other aim or purpose, forever? As we have already noted, if we did grant that the thing *I* must, for some super-rational reason (whatever that is), proceed to the body *N* when liberated from *M*, then the mere incorporation of *I* with *N* still leaves the real problem unsolved. In fact, our Case I (a) reduces to Case I (b) as depicted in Fig. 12,

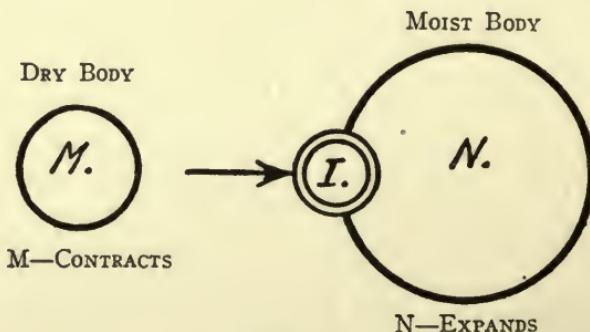


Figure 12

wherein our inquiry involves an unexplained "rapport" between *I* and *N*. The existence of *I* in the interstices or voids of *N* is not a sufficient reason for a change in *N*. The things *I* and *N* may be alien and inimical in their real nature.

The friendly services of the phantom "rapport" cannot span this irrational gulf, because we must insist upon "rapport's" credentials and we must know somewhat of its method and manner of operation.

70. CASE II. INFLUENCE I, A FORCE, STATE, OR ACTION

The attempt has often been made to avoid the difficulties of Case I by asserting that the mobile influence is either force, action, or state, and that *I* is not a thing.

This assumption causes us to inquire how a force, state, or action *I* can separate itself from the body *M* and exist for even an infinitely short time as the force, state, or action of neither *M* nor *N*. What determines the direction of *I*? Why should *I* show a preference for *N* instead of any other body *R* of Fig. 13?

The idea that *I* is able to show a preference involves the idea of a choosing consciousness, and we are lifted from the plane of matter to a plane of non-matter, mind, or spirit.

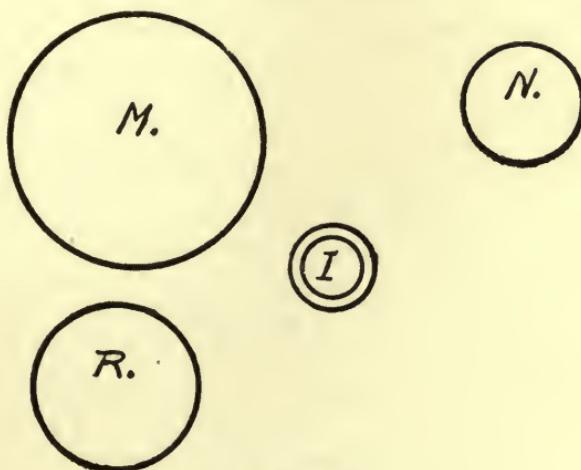


Figure 13

We must here emphasize this fact that our entire discussion, viewed retrospectively, at some point in the analysis brings us face to face with an unknown something, other than matter, partaking of the nature of a selective consciousness.

If we suppose that at the time of the transition of *I* the body *M* is subjected to a counteraction from *N* which directs *I* toward *N*, then we are brought back to the original query, how *N* can influence *M* through an intervening distance, and how *N* can direct *I* in its motion from *M* to *N*. It does not help the difficulty if we reverse the order of the bodies in the above questions and cast the onus of the phenomena

upon *M* instead of *N*. Moreover, why should not *I* continue on forever in its voyage through space without becoming the state of *N* or *R* or anything else? If this is not the condition which is produced, and if *I* actually does travel to *N*, then we are again confronted with the idea of a selective power of an intelligent order, which we must ascribe to either *M* or *N*, whereby the direction and length of the path of *I* are determined. This means that our original problem is once more before us; that is, the problem of how *M* or *N* can affect *I* at all.

71. CASE III. CONTACT IN SPACE

We show this case in Fig. 14, wherein the assumption is that contact is the indispensable preliminary condition for mutual action. This assumption, however, is of no avail,

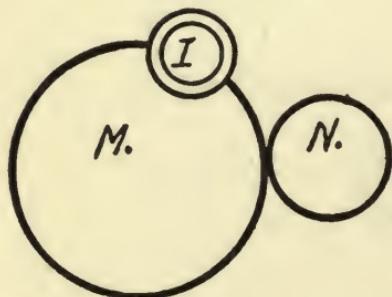


Figure 14

because we must explain why and how spatial contact causes previously independent and alien things, states, or forces to become interested in each other, thus producing the phenomena of change. Motion produced by impact in no way helps the matter, for mere "impact" is not a "potent something," but only an incident and an item amongst many others involved in change.

By the term *contact* we must confine ourselves to either the common boundaries of two objects constituting a surface without thickness, or a common point without extension. It is evident, then, that such parts as comply with our true definition of contact cannot produce motion in accordance with any precept advanced by science, for it can be only such molecular portions of the body as are not in contact with the other body which can produce motion in it. Thus we are again placed squarely before our fundamental problem of showing how distant particles can produce effects in other things. After contact has been established we must inject genuine action into the system by resorting again to some influence *I* as the active agent which causes change in the other body.

After contact has been established between *M* and *N*, without inquiring into the manner whereby this is brought about, the following represents some of the possible changes which may take place:

1. *M* may be absorbed by *N*.
2. *N* may be absorbed by *M*.
3. *M* or *N*, or both, may be disintegrated.
4. *N* may be set in motion in the same or some other direction than *M*.
5. *N* may remain immovable and *M* may exhibit motion in an opposite or some other direction.
6. Motion of both *M* and *N* may cease.

Since mere contact in space does not determine the choice between these or other possibilities, we face once more the ever present selective intelligent power which must be introduced to make change a reality in the world of phenomena.

We have seen that only those portions of a body which are not in contact with another body can, under the prevalent assumptions of science, be efficacious in producing motion, *consequently this very fact constitutes an admission that action at a distance is a reality. Action at a distance, however, is inconceivable if we assume that things are independent and unrelated entities.* Moreover, we have seen that an influence *I*, acting as a carrier of possible effects, is an impossible notion.

Therefore we are forced to give up the notion of independent things and to assert the mutual dependence of all centers of reality on an interacting unitary system.

72. The Monon.

What consistent description can we give to these ultimate centers of reality which we shall call *monons*?

The ultimate particles or monons must be genuine unities. The term *unity* cannot be applied to that which contains independent and unrelated parts so constituted that an experience in one part is *not* felt with equal intensity by all the other parts. Such a conglomeration is not a *unity* but a *multiplicity* of independent unrelated particles. A real unity or monon *M* must be so constituted that any effect or impression *i* upon any one of its points *a* must

simultaneously be felt with equal intensity (*i*) throughout the entirety of *M* as a state of all of *M*. If the ultimate monon *M* is of such a nature that the state or impression *i* must be transmitted from point *a* of *M* to point *b* and then to *c*, from one point to another throughout *M*, then this construction upon *M* is nothing more than our ordinary conception of a number of distinct and separate parts or entities, for effects are supposed to be transmitted just in this manner from a separate entity *a* to another entity *b* and so on through the series involved. Consequently the concept of a real, genuine, unitary monon *M* must not involve the idea of the transmission of an impression *i* from one point *a* to another point *b* of *M*.

The impression *i*, whatever be its nature, must be simultaneously felt throughout *M* with *equal intensity* without the aid of a process of transmission. If the impression *i* be in the nature of a motion, then the motion *i* imparted to a point *a* of *M* must also be, simultaneously, a motion of the point *z* of *M* located diametrically opposite to *a*. In other words, *no time* must be consumed in communicating the motion from point *a* to point *z* along the line *az* of a monon *M*. Moreover, the intensity of the effect at *z* must be equal to the intensity at *a*.

The three elements introduced into the concept of the monon *M* are as follows:

1. Unity.
2. Extension.

3. Equality of the intensity of imposed effect throughout the monon.

Actual data of experience constitute the only legitimate test by which the validity of these three elements may be determined. The data of experience present nothing adverse to the notion of unity. Every notion formulated concerning an ultimate particle pictures it as an entity and a unity, but the scientific concept of such a unity is not a critical and consistent concept; the word is merely *thought* without analyzing the implications.

The element of extension is taken for granted by all scientific positions. It is regarded as the primary fact of experience. The third element which we have introduced as a necessary and inevitable factor in the construction of a

real monon is not borne out by the data of experience if the *equality* of the *intensity* is associated with the second element of *extension*, because experience teaches us that the intensity of a force varies, in some manner, with the distance between the particles. An ultimate particle composed of disparate independent parts, we have seen, is of no value in formulating the conception of a real unitary monon. It is evident that the data of experience force us to give up either the second element relating to extension or the third element relating to the equality of the intensity. We prefer to give up the notion of extension, for it only involves us in an inexplicable multiplicity of parts, and does not involve a potent dynamic factor which is the paramount element in the universe. Eliminating the second element, we retain for the monon the two mutually consistent elements:

(a) Unity.

(b) Equality of the intensity of imposed effect throughout the monon.

In other words, for us, *unity* and *activity* are the vital elements of the monon; extension in space is merely a mode in which this active, dynamic, and unitary reality exhibits itself in the phenomenal world. Extension, *per se*, is not an independent dynamic principle of the world; it is impotent in the production of phenomena; it is merely one of many modes in which the real manifests itself. It is a variable phase of activity. Consequently, we do not hesitate, when consistency demands, to give up this notion of extension as an invariable quantum in connection with our center of reality, the monon.

We therefore reduce the world to a system of unextended centers of reality or activity, the monons, which affect each other at a distance. Through interaction the monon exhibits extension.

The phenomenon of gravitation comes to our assistance in bringing physical evidence before us which substantiates our assertions. Gravitational activity is instantaneous. If gravitation were a phenomenon which required time for the realization of its activity, then the orbits of the planets would not be closed curves but spirals along which the planets would progress outward from the sun. Even for a

velocity one million times greater than that of light, changes in the orbits would have been observed by astronomers. Since tendencies to an outward motion have not been observed during historic times, we argue that gravitation is not a time phenomenon, but an activity which is instantaneous in its effects.

All that we have said concerning the problem of physical action holds equally well for the ganglionic and commissural nerve-tissue of the brain. All the conclusions pertain to these forms of activity centers with equal validity.

73. The Unity of Things.

We may represent the sum total S of all cosmic reality by

$S = f\{a, b, c, \dots, R\} = f\{\text{Unity}\}$, or $S = f\{R\}$.

In such a system a change a is not merely a change of one element A , for the reason that to extend the consequences of this change in A to another reality B , a medium of transmission is required; but it is a change in S without the necessity of a lapse of time t before it becomes a change in S . By the reality S we mean an infinitely greater reality than the mere content of our thought, for that content deals merely with the eternally subsisting relations of the knowable. Reality is forever something more than thought. We regard R , in the expression

$$S = f\{R\},$$

as the animating energy of the world, the manifesting dynamic principle of the cosmos, whereas the manifestations, known, unknown, and possible, are represented by S . Our expression is an equation, therefore we are not divorcing content and reality. For us content and reality are one, and S is merely a function of R .

A crude mathematical analogy to the interaction between activity centers in this unitary system called the cosmos is found in the infinite series

A successive summation of terms gives us

$$\frac{1}{2}, \frac{3}{4}, \frac{7}{8}, \frac{15}{16}, \dots \dots \dots \frac{32767}{32768}, \frac{65535}{65536}, \dots \text{approaching } 1.$$

The summation is an infinite process which cannot be accomplished in time. Nevertheless, we know definitely

that if we continue the summation indefinitely the total sum can never exceed unity. There are possible an infinite number of terms; nevertheless, the sum of this inconceivable totality cannot exceed unity. Suppose, now, that a change in the first term occurs so that $\frac{1}{2}$ becomes $\frac{1}{3}$, then this may be compensated by a change in the second term from $\frac{1}{4}$ to $\frac{5}{12}$; in other words, the first term has been decreased by $\frac{1}{6}$ and the second term has been increased by the same amount, consequently no change in the totality of *S* has occurred. Innumerable similar compensating changes may be imagined to take place in any or all the terms of *S* without affecting the total which *S* represents.

It is evident that this crude analogy cannot do justice to what we desire to express by *S* being a function of *R* and equalling unity, for we never will be able to state the complete significance and import of the idea *R* which we regard as the vital principle of the universe.

We find in music another analogy for the unity which we assign to *S*. An orchestral production is a unitary structure similar to *S*. The orchestral composition is cast about a tonic or keynote. Its part movements clamor for resolution, its modulations, anticipations, and cadenzas constitute harmonic structures postulating and necessitating each other, while the entire structure is, verily, a prayer for the return of the tonic.

In the personal ego we shall observe our most perfect analogy of the unity which we ascribe to *S*. A conscious ego *E* comprehends, in conjunction with an act of the senses, the existence of an *a* both as a something which enjoys an individual existence of its own and as a genuine state of the ego *E*. The continuous ego reveals to itself, through memory, both past and present as being the property of that particular ego. It is this unity which persists through a multiplicity of changing states, exemplified in the conscious ego, which serve as the microscopic prototype of the unity which we associate with the idea *S*.

The idea *S* includes within its unity all types and degrees of self-affirmation, from the conscious self to the lowest form of a material unit. Within *S*, a thing, therefore, is merely one of its elemental activities.

74. Can Matter Act Where It Is Not?

Can a thing act where it is not? This question has deeply disturbed the meditation of the scientists. Those who have replied in the negative have presented the ether hypothesis as the only solution remaining. Let us investigate the implication involved in the terms of the question. The word "act" may be considered as involving two factors: (1) a change in the thing itself; and (2) an influence exerted by the thing which produces a change in some other thing or things. The word "thing" may likewise involve two notions: (1) that things are unrelated and independent; (2) that things are related and mutually dependent. If we mean by "act" merely a change in the thing *A*, then it is evident that the thing *A* acts only where it is. Similarly, a second thing *B* acts only where it is. If we mean by "act" both a change in the thing *A* and the generation of an influence *I*, then we are forced to admit interaction between mutually dependent things. This has been conclusively proved in the preceding. Consequently, if we adopt this latter meaning for the word "act," we are forced to the second conclusion concerning things, *i. e.*, that they are mutually dependent in an interacting unitary system. In addition to the above, our question involves the notion of space. The thing *A* is separated from the thing *B* by a distance *D*. Space itself may be interpreted in a twofold manner: (1) it may be regarded as a genuine form of reality capable of acting as a barrier to action; (2) space may be regarded as merely a form of apprehension by means of which the relative intensity of the interaction is measured.

The idea that an influence *I* passes from one thing *A* to another thing *B* has been shown to be an impossible notion. Physical science cannot point to one single instance where force has existed, even for one moment of time, as an independent entity apart from matter. Out of the above stated possible combinations depending upon the significance given to the crucial ideas involved in our question we may formulate the following four tentative assumptions:

I. That things are independent entities. That space is a barrier or insulator which prevents action at a distance. That the intervening distance between things may be overcome in two ways:

1. By the transfer through space of independent influences from one thing to another.

2. By means of a continuous ether which permits the transfer of motion from one point to another.

II. That things are independent. That space is not a barrier to distance action. In this case we dispense with the idea that independent influences are conveyed from one thing to another thing. This assumption involves the possibility of action at a distance and consequently a medium or ether is not required for the transmission of influences.

III. That things are mutually interdependent in a unitary interacting system. That space is a barrier to the transmission of influences. That the barrier may be overcome in two ways:

1. By the transfer through space of independent influences from one thing to another.

2. By means of a continuous ether capable of transferring influences from one point to another. Physical science ultimately reduces these influences to resultant motions.

IV. That things are mutually interdependent in a unitary interacting system. That space is a form of apprehension which serves merely as a relative measure of the intensity of the interaction. That space is not an independent reality capable of serving as a barrier to action, but that it is a form of apprehension by means of which the perceiving subject becomes aware of the relative magnitude of the interaction.

We shall now discuss the relative merits of the four assumptions:

Assumption I

We have already demonstrated the truth of the theses pertaining to Physical Action (see paragraph 68 and the following). We have shown that if we assume the independence of separate things, actions, states, or forces, then it is impossible to transfer from a thing *A* to another thing *B*, an influence *I*, whether this influence be a thing, action, state, or force. This thesis is true *not because space is a barrier which prevents action at a distance, or action at all, but because the very assumption that things are independent*

creates an insurmountable barrier against such a transfer. Space does not play the rôle of isolator of things in the sense of creating a barrier against action. The difficulty lies not in the real significance of space, but in the notion of the independence of things. The insertion of an ether or continuum between thing *A* and thing *B* is an attempt to unify *A* and *B* so that *A* shall be mechanically connected with *B* because of an auxiliary binding or connecting ether. By its introduction of the ether science admits the fact that physical action is inexplicable without the supposition of the unification of the discrete in an interacting unitary cosmos. The artificial mechanical concept of the ether, however, cannot unify discreteness. In fact, no mere act of thought can unify an actual physically discrete multiplicity. By this statement we mean that a thought product like the ether cannot unify that which is already assumed to be discrete, separate, and independent. We must consider the unity of things as a given fundamental of reality. When we admit this—and admit it we must—then the ether becomes superfluous as a unifying concept. The principal function of the ether is to bring about a condition of *uninterrupted and continuous contact*. We have already seen that contact in space does not help us to unify discreteness (see paragraph 71). Assuming continuous contact through and by means of an all-pervading ether, we are as far from an explanation of physical action as if we totally ignored the concept. Action at a distance is readily understood when we realize that things are related and interacting in a system which primarily was and continues to be a unity because of a creative and sustaining act of God. We conclude that the first assumption is untenable.

Assumption II

If we assume that space is not a barrier to physical action at a distance, this admission in no way helps us to understand the manner in which physical action is brought about if we persist in maintaining the independence of things. If things are independent, then the physical universe is eternally a chaos out of which nothing but the unintelligible can be derived. In a condition of chaos the causal nexus has no meaning and that uniformity which we describe in terms

of natural laws has no significance. The causal nexus and uniformity are unthinkable except in a cosmos which involves relatedness and interdependence in a system whose fundamental feature is unity. We conclude that whatever construction is put upon the notion of space, this construction in no way modifies the content of the notion of independence. The fundamental premise that things are independent vitiates any and every assumption concerning the nature of space. We cannot obviate the implications of "independence" by assuming that space is not a barrier to physical action. For these reasons we hold that the second assumption is untenable.

Assumption III

The assumption holds that things are interdependent in a unitary system in which the barrier to action interposed by the genuine reality space must be overcome. We have already proved that independent influences cannot be transferred through space from one thing to another. We have shown that the concept of the ether does not contain the solution of this desired transfer. Moreover, we do not admit that space is a genuine independent reality which is capable of acting as a barrier to physical action. Furthermore, the primary premise that things are interdependent in a unitary interacting system contains within itself all that is required to account for physical action. Space itself is not independent of interaction; it is not an alien entity foreign to interactions, but it is a form of apprehension which acquires significance through interaction. We, the perceiving subjects, described interaction in spatial and temporal terms. Since space is not independent of interaction, we conclude that the terms of the third assumption are mutually incompatible and hence this assumption also proves untenable.

Assumption IV

The previous conclusions point to the fact that the terms of the fourth premise are not only mutually compatible, but that they constitute the only premises under which physical action becomes intelligible. Thus we derive from another viewpoint the truth of the fundamental thesis of interaction in a unitary system.

75. The Transmission of Motion According to Physics.

A physicist once maintained that there are only two ways in which an influence can be transmitted from one body to another. In order to illustrate his contention he took the case of two ships *A* and *B* separated by a certain amount of water *W*. The two methods of transmitting an effect or influence would then be as follows:

I. The motion of ship *A* can be transmitted to ship *B* by means of the disturbance of the water *W* brought about by the initial motion of ship *A*. The water *W* set into motion by the movement of ship *A* communicates this motion to the ship *B*.

II. Ship *B* can be set in motion by the impact of a cannon ball fired from ship *A*.

The intent of both cases is to prove that action at a distance is impossible. We shall use the illustration to prove that both cases involve action at a distance.

The first case involves contact between ship *A* and water *W* and also contact between ship *B* and water *W*. The second case involves contact between Ship *A* and cannon ball *C* and also contact between ship *B* and cannon ball *C* brought about by the discharge of the cannon.

In paragraph 71 we have seen that spatial contact involves either the common boundaries of two objects, in which case the boundaries envelope a surface without thickness, or a common point without extension. It is evident that such parts of the contiguous bodies which comply with our true definition of contact cannot produce motion in accordance with any precept advanced by science, for it can be only such molecular portions of the body which are not in contact with the other body which can produce motion in it. Place two sheets of paper in contact and nothing in particular happens from the mere contact. No motion is produced because of the mere contact. If motion is produced, it is due to some genuine activity agency—the hand, for example—located back of the common surface of contact. Consequently the contact area between ship *A* and water *W* or cannon ball *C* and ship *B*, or powder *P* and cannon ball *C* has in itself no potency to produce motion. The motion, then, is due to those particles which are not located along the common contact surface. These particles may be either

conscious or unconscious activity centers. There is no evidence to substantiate the former supposition. All evidence points to the truth of the latter assumption. If the particles are regarded as independent entities, they must be endowed with the ability to choose and direct the type of influence and the direction of its motion to a preferred destination. This involves a conscious volitional activity which facts deny to the material particles. Interaction of interdependent centers in a unitary system is the only rational solution of the problem. The choosing of the spatial location and type of the action is not a conscious volitional act on the part of the particles, but it is a deterministic mode of interaction, describable in terms of the uniformities called natural laws, and exhibited in a unitary system which reflects a phase of the creative thought of God. The deterministic character of things which insures uniformity in interaction is due to the imprint of God's creative thought. This constitutes another proof of the existence of God. Returning to the consideration of the component particles of a body, we are reminded that science holds that bodies are composed of molecules, and molecules are composed of atoms. The atoms, in their turn, are composed of sub-atomic particles. None of these constituent elementals are regarded by science as being in contact with each other. On the contrary, there is ample distance between them all to allow for free orbital motions. Therefore, if motion results, it must be due to transmitted motion from particle to particle. But these elemental constituents of bodies never come into actual contact with each other or with the ultimate constituents of other material groups. Therefore action at a distance must take place between the elementals of bodies. Consequently what has actually been shown by the physicist, by the cases cited, is that certain conditions must be satisfied if this or any other particular phenomenon shall ensue. In the two cases mentioned the primary condition is that the distances between the elementals shall be small. According to science, real distances intervene between the elementals. Consequently effects, of whatever nature they may be, are realized at a distance. Therefore, to produce the phenomenon cited, we must comply with those governing relations which are the very foundation of the physical universe. In other

words, for the cases quoted, we cannot expect motion to result in ship *B* if ship *A* is placed in an empty portion of space far removed from ship *B*. The fact that this hypothetically empty space is devoid of matter is not the reason for the failure to produce the phenomenon; for whether the void be small, as in the case of the voids between the elementals of bodies, or great, as assumed in the hypothetical case in which ship *A* is placed in a vacuum far remote from ship *B*—in either case we deal with a void equally unconquerable for the physicist who obstinately refuses to grant the possibility of that which always is involved in physical action; that is, action at a distance. We draw the further self-evident conclusion that intervening distance is merely a measure of the nearness or remoteness at which a particular phenomenon may result. For instance, if we wish certain types of chemical action to take place, we must arrange conditions so that the intervening distances are exceptionally small in addition to providing for the free mobility of the particles. This we accomplish by solutions and the electric furnace. Space, then, is a chart of the relative interaction intensity values. Space is meaningless as an independent reality.

At this point in the argument the physicist produces his jug of ether, saying, "Let me pour this stuff freely into the universe and all your troubles are solved. My ether is the most pliable concoction imaginable. It is rarer than the rarest gas, but whenever occasion demands it becomes so rigid that it can withstand a pressure of 37,000 tons per square inch (according to Maxwell). In comparison with the rigidity of high-carbon steel, whose ultimate strength is about fifty tons per square inch, my ether is a giant. Fortunately for the planets and atoms, my giant, although over seven hundred times more rigid than high-carbon steel, is very sympathetic, and allows them to pass right through him without causing either him or them the slightest inconvenience or pain."

The purpose of the ether, then, is to do for a particle *A* and another particle *B* what the water *W* was supposed to do for the ship *A* and the ship *B*. The problem is identically the same in either case. In both cases it is an attempt to account for physical action through spatial contact. That

this attempt fails utterly has already been shown. Mere contact between particle *A* and ether *E* can never explain the transfer of an influence *I* from particle *A* to ether *E*. It is really an attempt to establish *interaction* and to create a *unity* out of the discrete particles of the universe. No artificial thought product like the ether can ever unify the physically discrete. If the unity does not actually exist, then a mere thought concoction can never produce a genuine physical unity. We maintain that the unity of things is a real given exemplified in interaction. Therefore we need no artificial ether concept to unify the physical universe.

Finally, the physicist will maintain that all is ether and that the discrete particles are merely manifestations in the ether and of the ether. This is his final and most consistent attempt to produce unification. Unfortunately, he must localize the disturbances in the ether in order to give a semblance of physical reality to his ether particles. In other words, he introduces discreteness into his continuum and thus breaks down his own parent concept. If there be no discreteness, then the empty void is as potent a notion as the continuum or ether. The moment, however, that the physicist localizes the ether particle, differentiates it, as it were, into discrete nodes, vortices, centers, waves, or what not, then he is face to face with all the difficulties already considered under the caption of "The Problem of Physical Action" (see paragraph 68 and the following). He must show how an influence *I* can be properly transferred in the right direction and through the correct distance from an ether center *A* to another ether center *B*. If the ether centers be regarded as independent, then this ether concept will involve the same insurmountable difficulties as are met with in the case of empty space. If he admits our primary contention that the ultimate centers, whatever be their nature, are interdependent and interacting in a unitary system, whatever be the nature of that system, then his ether becomes superfluous even if it could be made to be self-consistent. We have shown that the ether is far from self-consistent. We have shown that physical action is impossible except under the assumption that the physical universe is a cosmos of related interacting things. For the above-stated reasons we hold that the ether is inconsistent and

superfluous. Consequently we maintain that the physicist has failed in his attempt to unify the physical universe by the concept of the ether. It follows that he has no alternative left but the acceptance of the truth of action at a distance.

CHAPTER V

THE MODEL OF THE PHYSICAL UNIVERSE ACCORDING TO THE SPACE-TIME POTENTIAL

76. The Real Purpose of the Ether.

There are almost as many ethers as there are physicists. Certain resemblances to matter are evident in every ether hypothesis. The ether model is, in fact, always based upon certain fundamental properties of matter, reduced either to zero or raised to the n th power. The continuous occupation of space seems to be common to all of them. Matter is here and there. Ether is supposed to be everywhere; hence we have, in the notion, the space occupation of matter raised to the n th power. The ether is a kind of maximum and minimum of matter properties. The theory was first announced by Huyghens and later it was developed by Young and Fresnel. At the outset it was a protest against the emission theory of Newton. If it is thought of as a solid, it is endowed with incompressibility. Other thinkers ascribe infinite compressibility to the ether; in either case, matter properties extended to an ultimate limit. F. Neumann and MacCullagh adhered to the incompressibility notion, while Fresnel preferred the hypothesis of infinite compressibility. Hertz refers to it as an isotropic, homogeneous and restraining medium. Lord Kelvin originated the gyrostatic ether model. We are told by some that the ether is structureless, incompressible, motionless, but capable of being set in motion, non-elastic, capable of indefinite subdivision, and that the resulting parts can move over each other without friction. No known reality in the universe satisfies these specifications. Empty space (vacuum) qualifies better than any form of matter. After all is said, *the ether is merely an imagined realization of the desire that at every instant there shall everywhere be something which is in intimate responsive connection with matter.* Sometimes the

ether is regarded, after the analogy of a fluid, as an infinitely compressible homogeneous fluid. Then again, the solid to the n th power becomes the model. As a solid it is considered by some as movable and by others as immovable. *Matter becomes the place of a single particle of this etherial substance.* By some the material ether particle is regarded as a hole in the ether, and by others as a vortex or a point of torsion. The elements of the ether concept, finding their original source in the properties of matter, are carried so far beyond the nature of this source that they become inoperative. It is further demanded of this ether substance that it shall serve as a medium for the propagation of all that varied class of vibratory motion which apparently fails to find an adequate explanation under the old emission theory. Then again it seems desirable that the ether shall be capable of exerting pressure upon such moving elementaries as electrons. This is particularly true in the theory of Lorentz. The difficulties encountered in reconciling these demands placed upon the ether model, constructed from the physical properties of matter expanded or contracted so far beyond the bounds of reality that they become either inconceivable or self-contradictory, are so insurmountable that many serious investigators have concluded that the notion is totally inadequate properly to correlate the ever-growing array of experimental facts.

The apartness and independence of matter is the basic fact underlying the desire "that at every instant there shall everywhere be something which is in intimate responsive connection with matter." Is there that which can accomplish this without including the objectionable elements in the ether model? Many facts point toward fruitful channels along which consistent development may proceed. If we abandon the idea that material centers are self-sufficient and independent except under localized conditions, then we have removed the greatest difficulty in the way of understanding any and every type of phenomenal activity. In other words, admit interaction in a unitary system of inter-related centers, and the terrors of the vacuum disappear. It was this very dread of a vacuum which called forth the desire that "there shall everywhere be something."

77. The Concurrent System.

In the further development of our model to meet the requirements of class phenomena, we must adhere completely to those basic distinctions and properties which constitute our concept of matter. We must neither minimize nor maximize these properties. Were we to find that matter is materialized energy—that is, an ultimate particle is a work center—this discovery (already a fact) must not and cannot affect the nature of that primitive content of matter which we shall employ in our model. The concurrent system or vehicle we desire can be ultra-material only in the sense that it may be constructed from the very ultimates of matter. It must not be ultra-material in the sense that we can carry the properties of matter to their zero or infinite limits. Our concurrent system, composed of the ultimates of matter, may be thought of as emanating from or concentrated within matter in accordance with the requirements of the particular activity.

The motions of these ultimates must be connected with the motions of their related matter groups. Through the varied relations between bodies we may know these vehicle ultimates, if not in their direct effects, then through their indirect effects. The further extension of the concurrent system along surfaces in space may be contemplated as consisting in the interaction of the ultimate centers disposed in configurations which insure equilibrium. Such spatial surfaces would constitute resistive fields of centers interacting at a distance, for matter is discrete and not continuous. Motion cannot be comprehended upon any other basis than that of actual observed motion, which always presupposes discrete particles capable of genuine displacement for the very reason that they are discrete. Action at a distance, regarded as interaction between related centers in a unitary system, far from being inconceivable, is the only assumption which is consistent and in accord with reality. In the gravitational activities we have a universal exemplification of action at a distance. All attempts which have been made to escape this conclusion concerning gravitational action have had recourse to the ether hypothesis, which, as we have seen, contains the seeds of its own destruction.

78. Fields of Interaction.

The resistive fields are really fields of interaction which may be regarded as both resistive and receptive. Space may be considered as laminated in every direction with such fields. Empty space has no meaning from this point of view, for the reason that every surface in space is subjected to interaction, which results in giving to every one of its points a definite work or energy value. The motion of a particle within a given surface can be definitely predicted if we have a prevision of the work value of the points in the surface. Our model, therefore, may include, without inconsistency, planes and surfaces free from ultimate centers because such planes will still have definite energy significance for every point within them. If a particle *A* moves into an interacting field containing *n* ultimates, then the future motion depends upon: (1) its actual position in the field; (2) its mass; (3) its velocity; (4) the force condition of the field due to the precise interaction at the moment considered. Moreover, the force conditions of the field depend upon: (1) the precise location of the *n* ultimates within the field and their complete interaction, which must include themselves and all the other ultimates; and (2) the previous motion and interaction condition of the particle *A*.

79. The Scientific Renaissance.

When the true nature of the electron was established, science was born again. Matter was then forever dethroned and the energy phase was restored to its rightful heritage in the realm of knowledge. Seers like Ostwald realized the truth that energy is the inclusive action phase, while matter, as a separate independent entity, is the phantom of the imagination. It remained for J. J. Thomson to demonstrate this experimentally. As one manifestation of energy matter is truly real, but as something alien to energy, a dark unrelated background for the drama of physical action, as such matter has no reality. Matter is of energy, not independent of energy, and energy itself is merely a phase of interaction.

This epoch-making discovery began with Varley's observations of the cathode rays which are given off at the

cathode in a vacuum tube filled with a very dilute gas when electricity is passed through the tube. These cathode rays travel with great velocity from cathode to anode, and they carry a negative electrical charge. They are deflected in the same direction in a magnetic field as negatively charged particles. Thomson showed that cathode rays behave like negatively charged particles in an electrical field. Thomson called them "corpuscles." Johnstone Stoney named them "electrons." It has also been shown that the beta rays given off by radium are, in fact, nothing but electrons. The mass of the sub-atomic electrons remains practically constant at about ($1\frac{1}{4} \times 10^{-27}$ kg.) of the mass of the hydrogen atom, provided that the velocity remains within certain definite limits. Beyond the extreme limit the variation in the mass of the electron is marked, and experimental evidence has shown that the mass then increases with an increase in the velocity of the electron.

To Kaufmann belongs the credit for this astounding discovery, which, in the hands of Thomson, gave us a new conception of matter. *The startling fact is that the actual mass increase is exactly what it must be if the mass is entirely electromagnetic.* The electronic particles are deviated by magnetic or electrical forces. The amount of this deviation, the charge transferred, and the heat developed constitute some of the basic data from which the mass of the electron is determined. In the Newtonian dynamics we have seen that force is the product of mass and acceleration under the supposition that the *mass remains constant*. For the electron the Newtonian law apparently holds good while the mass remains constant. The old expression must be so modified that it will provide for this variation in the mass. The old Newtonian expression involves one constant and one variable; the modified Newtonian expression must include two variables. These radical discoveries have completely effaced the dogma of a fixed and solid atom. The invariability of mass is gone forever.

80. The Normal Materialization of the Concurrent System.

Can the concurrent system be transformed into normal matter? In order to answer this question let us consider a simple device composed of a horseshoe magnet whose two

branches culminate in a single cylindrical shaft very much like the shape of an ordinary tuning-fork. The cylindrical shaft is provided with a bearing in a vertical conducting support which is properly insulated from the base of the apparatus. A crank is attached to the end of the cylindrical shaft. Parallel to the ends of the horseshoe magnet we erect an iron plate in a vertical position, taking care to insulate this also from the common base of the device. A copper wire is connected with the iron plate. Another copper wire is connected with the conducting vertical support. Ordinarily we say that the iron plate opposite the magnet is magnetized. Moreover, this induction reacts upon the magnet, apparently strengthening its magnetism. The positive and negative poles of the magnet produce respectively negative and positive poles in the plate. We assume that the space between the generated magnetic poles in the iron plates and the poles of the magnet contains the primary matter of the concurrent system. By the term "matter" we mean an action center or group of centers. An action center is a mass-acceleration center according to the force-center theory of Boscovich. Primary matter is capable of phase transformation. (This will be discussed in detail later.) By the expenditure of work *primary matter can be transformed into secondary or normal matter. The electron is the unit of normal matter.* The atom and molecule are aggregates of these normal matter units.

Let us now connect the two copper wires, establishing a complete circuit through some device which will tell if a current of electricity is produced. Nothing happens. Now let us turn the crank of the magnet vigorously. The instant that we do this, something happens; in fact, we produce an electric current which can be made to do many kinds of work. We observe further that effort is required to turn the crank just as if a resistive pressure were being applied to the shaft. When we cease turning the crank the electric current ceases. The magnet and the iron plate show no loss of material whatever, indicating that the current is not produced by modifications of that type. In fact, the electric current generated is due to the expenditure of energy involved in the turning of the crank against a resistance. Now the new school of science tells us that an electric cur-

rent is merely a flow of electrons. It is incontrovertible that the expenditure of nothing but energy, in our device, has generated an electric current, which means a flow of electrons. Two questions will occur to us: (1) Did we actually make these electrons and also set them in action by expenditure of energy? (2) Did we merely set them in motion? According to the new school, all matter is made from electrons, and an atom is a miniature solar system wherein the electrons are the planets. Perhaps the electrons which constitute the current of electricity are detached from the magnet and the iron plate, and the energy expended, in our device, is required to separate them from the iron atoms and to keep them in motion. If continuous work is to be done in the external circuit, a continuous flow of electrons must be maintained. This means the ultimate complete disintegration and dissipation of the iron atoms, which is not borne out by fact. Unless there is some other source of supply of electrons, it would seem that our device actually converts energy into electrons. From the new viewpoint this is not alarming because it is conceded that the entire mass of the electron is of electrical origin. We can, then, take the position that every point in space exhibits, or is capable of exhibiting, a definite work or energy value, thus constituting an interacting etherless system, able, under determinate conditions, to produce that change and transformation of energy which we call matter. Nothing of real import can be maintained against this view; in fact, it must remain as the basic groundwork of any hypothesis which is to do justice to physical action. However, the value of a physical model must not be underestimated because of the possibility which it provides for previsions and subsequent progressive corrections.

The model of the concurrent system composed of primary matter must therefore be conceived as having already present within it partially developed energy manifestations located at positions compatible with ascertainable physical requirements. Interaction between the intrinsic energy of the concurrent system and the extrinsic energy associated with already developed matter groups may, then, produce amplification and more complete development of the energy factors of the concurrent system.

81. The Monon.

Indications point strongly to the conclusion that all phenomenal manifestations of energy ultimately prove to be of the kinetic order. From this standpoint our spatial background is a chart of potential energy values in which kinetic energy of definite magnitude is manifest at definite positions or points. At such positions, then, we must locate our activity of kinetic energy centers, which, for want of a definite name, we may call *monons*. We must ascribe to these monons such basic properties as form the fundamental requirements of possible matter. The monons, in addition to being energy, are potential normal matter. Therefore we assign to them the fundamental property or capacity of exhibiting resistance to that which tends to give them acceleration; in other words, we attribute kinetic reaction to them as their basic phenomenal property. Since the concept of kinetic reaction includes the idea of resistance, we have at once the negative feature of our monon; and since they are capable, through their own positive content of kinetic energy, of exhibiting interaction, we also attribute a positive nature to this ultimate element. Interaction requires the unified presence of both the negative and the positive nature in the monon, the former to insure its self-preservation and survival, the latter to provide for possible attractive manifestations. This is, in fact, what interaction means, repulsion and attraction, reaction and action, unified in the content of the monon. We cannot conceive of the independent existence of either the negative or the positive function within the primary unity. Complexities built up of monons must behave in this twofold manner. Complexity does not prohibit unity: it is unity of a higher order ascending until consciousness is attained. The universe itself is the highest physical type of unity in complexity.

Since kinetic reaction involves a possible mass coupled inseparably with a possible acceleration, we include these factors in the concept of the monon with full realization that mass and acceleration are naturally dependent variables capable of all the shades of variability from zero to a possible maximum. Within certain critical values we may therefore find that the variation of the mass is practically reduced to its zero limits; in other words, below this critical

value the mass may appear to be maintained at a constant value. We do not, therefore, regard the monon as an absolutely fixed and unchanging ultimate. Moreover, as a center of static influence its scope of activity must include a maximum and minimum sphere within which limits expansion and contraction are possible. We look upon the monon as being capable of this form of pulsation between definite limits. The monon, then, is energy manifest within definite limits responsive to the general law of interaction.

82. The Energosial or Concurrent System.

The further development of our model requires that its kinetic energy be defined, in part, in terms of motion, for the reason that all physical phenomena are ultimately reduced to terms of motion. This involves the existence of gyration groups of monons. If our concurrent system, or *energos* (meaning "active" or "in work"), is energy, it does not become necessary to think of the manner of the beginning of these gyrations, because they are merely one means of exhibiting this eternal energy. The maintenance of the gyration is no more the problem of science than the seeking for a cause or manner of the beginning. The continuously given world involves the continuous presence of energy. The continuous maintenance of energy forces us to admit the immanence and transcendence of that activity principle known to philosophy as the Absolute and to the religious consciousness as God. If our model becomes a better interpreter of physical action by adding to it the idea of gyration groups, then we must consider them also as continuously given because they are our mechanical symbol of an ever-present energy. This does not preclude variations in the velocity and size of the gyration orbit; in fact, this must be assumed if our model shall, even with partial success, portray physical action. Moreover, we must include the possibility of dismemberment of the groups, involving curvilinear and rectilinear motions of the dismembered centers. We do not desire, therefore, like Helmholtz and Kelvin, to maintain the eternal gyration of our groups. The condition of a group is not only due to self-determination, but it is also dependent upon other interaction factors. The maintenance of the world is provided for in the con-

tinuous manifestations of our concurrent system, the *energos* together with the conservation of those matter groups which we may regard as external to this system. This continuous manifestation is grounded in the concept of God.

83. The Gyratory Energons.

Gyratory Groups

A rotary system composed of diametrically opposite monons constitutes our simplest gyratory group. In order to refer to this group type we shall call them *energons*. This name will suggest their origin in the "energosial" system. Far from the influence of disturbing matter groups, the diameter of the energons will be practically equal to each other and constant. If a body is free to move in a plane wherein the components of the activity intensities due to the external system, resolved along suitable reference axes, are equal to each other, then it will move in a circular orbit. If these component intensities are unequal, the orbit will be a conic section. The monons constituting the energon are therefore free to move in the same circular orbit if the component activity intensities of the system external to themselves are equal to each other. In other words, the nature of the orbit may be considered to be governed by the external activity factors. We may look upon the result as a centripetal effect tending to maintain the monons in a constant radial relation to a common center. If we neglect the part played by the monons, our concept will be incomplete. The energon and the external system interact continuously. In this case, then, the rôle assigned to the monons would be one of mutual repulsion, which, in reference to the external system, would constitute a centrifugal reaction. A central force would produce the same result both in respect to the type of the orbit and the action intensities, provided that the effect of the system external to the energon be totally disregarded. We cannot disregard the entire universe for the sake of merely establishing the rotation of one of its groups, consequently we are forced to look upon the gyration as being due to the interaction of both the external system and the energon as heretofore set forth. The

external system would therefore exhibit an intensity of action equivalent to the kinetic reaction developed by the rotating energon. From another viewpoint, the reaction of the concurrent system is equivalent to the centrifugal force of the energon. The concurrent system and the gyrating energon, therefore, exist in a condition of "dynamic equilibrium." An influx of energy, due to the action of a material group, into the energonic system would be in the nature of an increase in the centrifugal force causing an increase in the radius of the energon.

84. The Birth of the Electron.

Let us again refer to our current generator. First we must consider the rôle played by the constituent members of the device. From our present viewpoint we regard a magnetic substance as capable of exhibiting exceptional permeability to the flow of energons. The process of magnetization consists in an axial alignment of the atoms constituting the substance. We regard the atom as composed of a large number of sub-atomic particles playing the role of planets in the atomic solar system. More precisely, we may think of the orbits as a series of rings or loci whose planes are parallel to each other and perpendicular to a common polar axis passing through the ring centers. The energons continuously rotate during their passage around the ring loci orbits. The plane of an energon in the orbit is perpendicular to the ring locus tangent at every point in the locus. The distance between the rings is a potential function of energy of the rings. In other words, there is a definite potential difference between the rings, compatible with the maintenance of the atom as a comparatively stable structure in an interacting system. This is also true of all sub-atomic groups and distances. In a magnetized substance the polar axes of the atoms have been aligned and energons may therefore invade such atoms with greater ease than in a non-magnetized substance. An iron disk, in the presence of a magnet, affects, and is affected by, the energonic displacement in the atoms of the magnet. If we drop a body into a vessel containing water, the level is displaced. Similarly by introducing a piece of iron into the field surrounding a magnet we disturb the equilibrium of the field. The

disturbance of the equilibrium is equivalent to increasing the stress in the concurrent system. This induces polarization of the atoms constituting the iron disk. The normal distance between energonic rings is decreased, due to the intrusion of the iron disk. Furthermore, some of the energonic rings invade the now polarized iron, thus tending to relieve the increased stress in the concurrent system. The tendency to relieve the congestion is concomitant with a further decrease in the ring distance which is equivalent to shortening the axial ring line through magnet and iron disk. This is accompanied by a tendency to translate the iron disk toward the magnet. The loci of the energonic ring centers constitute what we generally mean by a line of magnetic force. These loci are merely spatial representations of the directional resultants of interaction. When we use the term "line of force" we mean that this significance only shall be attributed to it.

From electromagnetics we know that if we look along a conductor in the direction in which the current is flowing, the lines of magnetic force around the conductor are in a clockwise direction. This means that the energonic rings travel in a clockwise manner in the orbits surrounding the conductor. While their centers advance along the lines of force (the loci of the moving centers constitute the lines of force), the energons themselves rotate in a clockwise manner. For a reversal in the current direction the orbital motion is still clockwise in reference to the new current direction. This orbital direction will therefore be counter-clock-wise in reference to the previous rotation.

The effect of an energy increment and an energy decrement in relation to the potential status of the energon must now be considered. Physical interaction demands that the energon be capable of passing through three phases or states. In the undisturbed concurrent system the phase is neutral, and for this state the magnitude of the intrinsic energy, the centrifugal force, and the radius of the elementary system constitute determinants which define the energon in its neutral state. In fact, in the neutral phase the term "energon" includes these determinants. An increment of energy applied to the energon involves an increment in the determinants. A decrement of energy, similarly, in-

volves a decrease in the determinants of the energon. There is a maximum and a minimum limit to the magnitude of the determinants, corresponding respectively to an increment and a decrement of energy. The energonic system may change in a twofold manner from its neutral condition. The ascending process involves a definite work increment; the descending process involves an equal work decrement. The three phases, then, may be designated as the *high*, *neutral*, and *low*. Passing from high to neutral or from neutral to low is a descending process involving compression. If the change be in the reverse direction, we have an ascending process which involves expansion. The ultimate unit of work is that work which is involved in the change in phase of the energon from neutral to high or from neutral to low, irrespective of the direction in which the change takes place. The three phases involve two steps which may be traversed in either direction. Irrespective of direction, each step involves the same amount of work. The ascending and descending processes are inseparable in all phenomenal action. The development of an ultimate unit of work increment involves the compensating appearance of an ultimate unit of work decrement. The energonic reactions therefore always involve a pair of energons. For the same reason molecules in solution are broken into couples. A unit of work increment applied to one energon involves the simultaneous appearance of a unit of work decrement in another. The work expended along the ascending potential gradient is equal to the work stored along the descending potential gradient.

In the *high phase* the energon becomes an *electron*. In the *low phase* the energon becomes a "*positon*." The word "*positon*" indicates that the energon exists in that phase which is the extreme of the electronic. Moreover, a *negative charge* is always associated with the free electron. We associate an equal positive charge with the positon. In the last analysis the magnitude of this negative and positive charge depends upon the work increment and its equivalent work decrement. Work expended is always equal and concomitant with work stored.

Ions in solution exhibit these three phases in accordance with the precise phase change in the energon. In other

words, the phase change in the energon is the factor which determines the phase of the ion. Since all interaction presupposes the concomitance of both the ascending and the descending processes, it follows that the products of solution must appear as ionic pairs. An odd solution component cannot remain in solution. In this we have the real reason why molecules break down into so-called "ionic pairs." We cannot accept that contention of the electrolytic theory of dissociation which holds that the ionic pairs in solution are charged in an opposite electrical manner.

85. The Electric Current as Transformed Mechanical Energy.

Our concurrent system model is now sufficiently complete to test its usefulness not only in the interpretation of the phenomena connected with our little current generator, but also in the elucidation of electrolytically generated currents. The author has also applied the model in the interpretation of the phenomenon of light. These applications of our model are discussed later in the text.

Let us now consider what happens when we turn the crank of our generator. It is evident at once that we disturb the energonic axial force lines the moment the magnet is rotated. These energonic force lines form closed curves. The energy configuration offers resistance to the disturbing influence. The work done by the material group is of the nature of an ascending process, adding energy to the electronic groups, which expand and thus become electrons. For every electron thus formed in the concurrent system, involving the expenditure of an ultimate unit of work increment, an energon is reduced to a positon, and an equivalent ultimate work unit is stored in the positon. Thus we have the ascending process concomitant with the descending process. The electron can again become a neutral energon by having an ultimate unit of work done upon it. Similarly, the positon can give up its stored ultimate work unit and again become a neutral energon. Hence work can be done in some material group system. The elecron, being at the high phase, can do no more work within certain critical velocity values, and it may therefore be regarded as negative. The positon, however, is positive in its ability to do work, for work has been stored in its production.

As the energon, due to the influx of external energy, becomes an electron, the surrounding concurrent system is subjected to expansion. Equilibrium in the concurrent system is restored by the formation of one positon for every electron generated. The equilibrium within the magnet itself is disturbed. As an energon expands into an electron it is displaced out of the magnet into the concurrent system. Simultaneously, a positon, concomitantly generated, passes through the electron into the magnet. This process is continuous while energy is expended in turning the crank of the machine. A stream of electrons moves along the new resultant force lines into the iron disk and thence into the conducting wire and the external circuit. Simultaneously, a stream of positons moves, at the same rate, in the opposite direction through the magnet and into the external circuit by way of the conductor. The positon is ready to give up its stored work to the external system and thus become once more an energon. At the same time an equal amount of work is done upon the electron by the external system transforming it also into an energon. The little current generator is therefore an energy transformer. It manufactures electrons and positons out of energons.

86. Primary and Secondary Matter in the Rôle of Concurrent and Excitant Systems.

Primary matter may, then, be regarded as activity groups arranged in conformity with the demands of interaction. The definite locations and phases of action of these centers depend upon the magnitude of the interaction at any given moment of time. Space, then, is merely a chart of apprehension which gives only relative meaning to activity manifestations. This also is true of time. Instead of space being a genuine reality which isolates the centers from each other and thus constitutes a barrier to physical action, space is merely a relative interpreter of the intensity of the interaction. Since the energy phase is our broadest physical concept pertaining to the activity content, we may think of these activity centers as localized energy. However, localized energy does not mean that the activity of these centers is accounted for by the mere word "energy," because the word "energy" signifies only a phase of that activity which

owes its beginning and maintenance to God the Creator.

Secondary or normal matter is merely transformed primary matter. In certain phenomena the elementals of secondary matter, like the electron, serve as *excitant systems*, which, in conjunction with the *concurrent system*, account for such manifestations as the phenomena of light and electricity.

87. Space Not Unreal.

Space is not a thing. Thought is not a thing. It does not follow that, because space and thought are not things, both have no reality. Because space is a form of finite apprehension, it does not follow that space is unreal. Like other types of finite reality, space is not independent. It is a form interdependent with reality. Space arises, as it were, out of interaction. As a form of apprehension or awareness it pertains to the knowing and perceiving conscious subject. Objectively it finds its significance in the interdependent activities manifest in the physical universe. Psychologically, the space form is a temporal genesis. Because of the fact of interaction between subject and object, the space form is general and not particular, and an *a priori* science of geometry is possible. Space is not an *X* which holds things in definite positions and keeps them either together or apart. The apartness and nearness of things are due, on the contrary, to an interdependent interaction. The separateness of things is due to the activity of things, and its magnitude is measured in spatial terms. We apprehend this separateness in terms of the space form and measure its magnitude in terms of distance.

88. Extension.

Since the space forms originate in interaction, the occupation of space is due primarily to the activity of things. The "how much?" of space occupation is answered by the "this much" of activity. Extension, therefore, is a form of action. It is a "this much" of action. Extension, however, is only one of many ways of measuring the amount or magnitude of an action. Consequently, it is merely one phase of activity.

89. Primary and Secondary Causes.

Reality is ultimately divided into an Absolute Reality and a relative reality, God and His created cosmos. In the rationally ordered physical universe the relationships between its members are intelligible in terms of space, time, and causation. The physical universe is a complete unitary system which differentiates itself into a temporal series of events appearing as antecedents and consequents. Causes and effects as known in the complete relativity system of the cosmos constitute what we have previously designated as secondary causes. The universe of physical action is causal and deterministic. The physical world is a world of uniformities and natural laws. The secondary causes are describable in terms of natural laws. Our own conscious activity is non-causal in the sense of natural law. We originate, and consequently our activity is in the nature of a "free cause." Our freedom is exercised within the limits of a causal and deterministic world order. The freedom of the Absolute is above these limitations. God's freedom is beyond the realm of secondary causation. Cause and effect in the sense of secondary causation are *of* God but not *in* God. We originate in a world of restrictions and limitations. Consequently our originations are of relative value and meaning. Our free originations and acts are brought into conformity with the deterministic mandates of environment by the inflexible coercion of experience. God's origination is Absolute and above all limitations. Our freedom is like God's, but only in part. An act or origination is our own free act, but its form is limited by the deterministic order of the physical universe. God's origination is free in an Absolute sense because it is above the unitary relativity system. God's free origination is therefore the only true primary causation. The being of God is a Transcendent Being free from the limits of relativity. We attribute the creation of the cosmos to the primary causation of God.

90. Physical Proof of the Transcendence of God.

The interpretation of the physical universe as a unitary relativity system results in an inert mechanical model. If we think of the physical universe as a fragment of a great all, unknown in part, then we have pantheism. If we con-

sider the universe as created by, but independent of, God then we have deism. Contemplating the world as a self-sufficient given, self-operative, and uncreated Godless system, we arrive at the position of materialism or atheism. Deism, atheism, and pantheism involve an inert mechanical model despite the supposed differences in the three positions. We have shown in paragraph 24 that the ultimate potential difference in the physical universe is maintained by God. Consequently the positions of deism and atheism are both untenable. Pantheism is merely deism raised to the *n*th power; it is an all-inclusive deism. The pantheistic "all" is no more maintainable within itself than the deistic or atheistic universe. The physical model of the pantheist is just as inert and inoperative as the deistic and atheistic model. It follows that a Being must exist independently of the physical universe, upon whom the cosmos depends for its continuous existence. Thus we arrive at a proof of the Transcendence of God.

91. Transcendence and Immanence.

It may be maintained that we have arrived at a repulsive dualism. We contend that the mere word "dualism" is no more repugnant than the word "monism." Inconsistency is the only justifiable cause of intellectual repugnancy. The objection may be raised that we have divided the totality of reality *T* into two parts, *A*, the Absolute Reality of God, and *S* the cosmic reality of the unitary relativity system. The relation, expressed mathematically, takes the form

$$T = A + S = A + f\{a, b, c, \dots, R\} = A + f\{\text{Unity}\}.$$

The unity of all reality established by the pantheist and the monist is merely a unity of multiplicity. The unity of the physical universe which we hold as a fundamental truth is a unity of multiplicity. The unity of the conscious self is a unity of conscious states. The unity of the monon is a unity of numerous phases, states, and qualities constituting a physical character content. Therefore all forms of reality exhibit a unity which is unintelligible without multiplicity. A unity which does not partake of multiplicity is merely a mathematical abstraction having no other significance. A

real unity, possessing a content, consequently is not a mere mathematical abstraction. Relatedness is the norm of unity. It is evident that the very idea conveyed by the term "relatedness" suggests multiplicity. The relatedness between mere numbers is nothing more than a mathematical abstraction. The type of the unity depends upon the kind of relatedness. We draw a sharp distinction between *unity* and *identity*. God and His created world are not identities. A relationship exists between God and the cosmos. It does not therefore follow that the cosmos and God are identical. Immanence and transcendence constitute the form of the relatedness between God and the world. This type of relatedness defines the form of the unity existing between the Divine Being and His created world. This type of unity does not signify identity. In the physical universe thing *A* is not identical with thing *B*. Nevertheless a relationship exists between thing *A* and thing *B* as well as between things *A* and *B* and the rest of the physical universe. Thing *A* is not therefore identical with thing *B* nor with the remaining things in the universe. God is not isolated from His created world. We have seen that ultimately the physical universe depends upon God for its continuous maintenance. God is the prime and ultimate sustaining cause of the physical universe. In the cosmos the imprint of God's Omnipotence and Omniscience is seen in secondary causation which guarantees order and uniformity in the physical universe. However, mere secondary causation is incapable of rendering the world intelligible. God must also be Transcendent, but not isolated from the universe. We have fathomed but a fragment of the causal nexus. The ultimate relationship between God and the universe is and ever will be a mystery to finite consciousness. Nevertheless, a real relationship must exist if we hope to interpret even a mere fragmentary portion of God's created work. Since God is not isolated from the universe, He may reveal Himself in time in a manner inexplicable to finite consciousness because of our limited and finite understanding of the profundities of the relationships which manifest in the cosmos. Because of our finiteness these Revelations may appear as nodes in the causal nexus. Because of our limited knowledge these nodes may be inexplicable in terms of uniformity. If this world

is nothing more than a machine, then uniformity is absolute. If our conscious life is merely mechanical, then free origination is impossible. Our conscious life is more than mere mechanism, consequently nodes of origination are possible. It does not follow that these nodes are therefore irrational. A nodal conscious life may upset the traditions of uniformity because of a deeper and more profound system of relationships. From the standpoint of uniformity, the inventive achievements of conscious life may appear to be miraculous. Since God is not estranged from the universe, His temporal revelations may appear as miraculous nodes when compared with physical uniformity. The mathematical law of a curve may include nodal points which break in, as it were, upon the general uniformity. For this reason the nodes are not unreal. From the Infinite viewpoint the revelations acquire a relatedness to the world order of deeper significance than mere mechanical uniformity. Since God is not isolated from the world, but is Immanent in it, His primary causation may deflect the general uniformities of secondary causation into nodes inexplicable to our limited, finite knowledge of the physical causal nexus. Such deflections, however, are in complete harmony with the deeper significance of reality. They are a fuller and more complete expression of reality in its ultimate meaning, and as such are in full accord with the principle of non-contradiction which unifies both primary and secondary causation. God, the Absolute, is the Infinite Perfection inspiring the imperfect. God is the unity of all truth. The fundamental characteristic of the Being of God is non-contradiction. The principle of non-contradiction actuates the physical universe and unifies primary and secondary causation. The general physical uniformities, known as *natural laws*, are fragmentary expressions of the all-inclusive principle of non-contradiction which demands the Immanent activity of God in such revelations as insure the realization of purpose and teleology in His created universe. These revelations are in strict conformity with the principle of non-contradiction which is the essence of the Being of God. When viewed from the standpoint of the fragmentary natural laws these revelations may appear as miracles, but from the standpoint of the all-inclusive principle of non-

contradiction they complete and harmonize the intent of reality. It should be evident that our position differentiates itself in a marked manner from the pantheistic, monistic, deistic and atheistic positions. In order that the distinction may be readily apparent, we resort to the shorthand of mathematics. In the above we have represented the totality of reality T by the following expression:

$$T = A + S$$

in which A is the Absolute Reality of God, and S is the reality of the cosmos. The various positions mentioned above may be represented as follows:

I. *Pantheism.*

$$T = A = S.$$

The totality T is identical and equal to the reality of God, or it is equal and identical with the cosmos. In other words, the cosmos and God are identical. The fallacy of this position has been pointed out in the preceding.

II. *Monism.*

$$T = A = S.$$

This formula is the same as for the pantheistic position. The monist may try to deny that he is a pantheist. With subtle verbosity he may try to create a distinction, but in the last analysis his formula reduces to the pantheistic. Monism is nothing more than a modernized pantheism.

III. *Deism.*

$$T = A + S.$$

The totality of reality T is divided into two distinct and independent parts; that is, the Absolute A and the cosmos S , created by God but independent of God. The cosmos is sufficient unto itself and does not need the existence of God for its maintenance. The fallacy of this position has already been noted. If S is merged into A , or A into S , then the deistic position becomes identical with pantheism or monism.

IV. Atheism or Materialism.**T=S.**

The totality of reality consists of the cosmos only. There is no God. All is mere matter and energy. This is the fallacious position of atheism and materialism.

It is clearly evident that pantheism, monism, and atheism, in the last analysis, are practically identical positions. There can be very little real distinction between the two statements, (1) that God is the cosmos, and (2) that the cosmos is the only existing God. Such apparent distinctions as are drawn are mere subtle sophistries. A mechanical model constructed upon the above outlined positions is inoperative. Deism fails totally in this respect because of its absolute isolation of God and the cosmos.

The results of scientific research, when properly interpreted, therefore force us to the theistic position as the only philosophical system which conforms with the results of the scientific method. The facts of science, when driven to consistent conclusions, force us beyond the relativity system of the physical universe to the Being of God in accordance with the philosophy of theism.

V. Scientific Theism.**T=A+f (a).**

In the philosophy of Scientific Theism we look upon the totality of reality as consisting of the Absolute Reality of God, *A* and the *dependent* cosmos *a*. The cosmos *a* is of God through the act of creation, but it is not God. Nevertheless, the cosmos *a* depends continuously upon God for its maintenance; hence we may say mathematically that *a*, the cosmos, is a function *f* (*a*) of God. In this manner we represent, in the shorthand of mathematics, the truth of both Transcendence and Immanence. The principle of non-contradiction is of the Being of God and in the being of the cosmos, first, through His act of creation, and, second, through His Immanence and Revelation. Primary free causation and secondary causation are harmonized in the all-inclusive principle of non-contradiction. The principle of non-contradiction manifests purposively and teleologically in the universe.

92. Purpose and Teleology.

Mechanism and natural law in the sense in which we have defined them are compatible with spontaneity, individuality, purpose, and teleology. As a mere machine the cosmos is inert, and there is no room for spontaneity and teleology. Uniformity means that every change is understandable as a variation in a rational system. Purpose implies that there are further adjustments necessary, more contradictions which must be resolved before harmonic relations with reality can be established. A purpose is right only in so far as it is in harmony with reality. The realization of a purpose means that conditions have been brought into conformity with the divine principle of non-contradiction. Consequently we may say that purpose is the intent of reality deferred in time. As far as the finite mind is concerned, purpose is no guarantee of value. When we have a vision of the whole, then we can discern the ideal which shapes the future. The future content is the result of the working of the ideal. The accidental is given fundamental importance in modern scientific thought. According to this hypothesis, a plant is an accidental by-product of the activities of elements which contained nothing in their individual nature or in their relationships that involved the slightest certainty that a plant would evolve. Such an hypothesis verges on the ridiculous and makes knowledge impossible. There is no valid reason why the accident hypothesis should be applied to the organic world only. If it is true, then it would be difficult indeed to assign a reason why it is not equally true in the inorganic world. From another standpoint, if there is some form of teleology assignable to organic phenomena, then that same form must be inclusive of inorganic and conscious phenomena. There must be *teleology below, in, and above consciousness*. The mathematical probability that accident could have brought about a cosmos is nil. Accident is the father of chaos, and intelligent, productive relationship is the father of cosmos. What we do find in the world is an unfoldment of an immanent reality. The plan of the plant was immanent in the entire and complete interaction of the universe. The plant did its part, environment did the rest, and between both there existed that perfect understanding which only God could give

to His created cosmos. The molding of the structure of the body or organism in the earlier phases of development cannot be ascribed to an inherent conscious knowledge existing in the earlier phases; it must rather be sought in the deeper inherent and hidden God-given endowment of the environment.

The great movements of civilization, the development of religions, of ideas, and of art find no counterpart in a plan existing in a finite mind. Finite consciousness plays its part in the deposition of the strata of civilization, but no finite mind ever grasped the significance of the grand totality, and consequently, as far as the great movements are concerned, finite mind is unconscious of the intricacies and multiplicity of its ramifications. There is intelligence in every step, but it is of an immanent order hidden deeper in the mystery of things than finite eye can perceive. This immanence points clearly to a Being Transcendent and above the physical order. Without Transcendence this immanence is inexplicable. The great movements are typical of a teleology above consciousness. In this we have another proof of God's Transcendence. Teleology finds its real meaning in individuality and completeness, which constitute the supreme essence of cosmic value, and as a finite conscious striving it is a temporal desire for harmony with reality. In this manner, then, does the principle of non-contradiction force imperfection toward perfection along the stream of contradiction and unrest.

CHAPTER VI

NON-NEWTONIAN DYNAMICS

93. The True Relation Between Statics and Dynamics.

If we regard space as a chart of potential values, then the behavior of a particle or mass aggregate is determined by its own work value interacting with the other work values in the field. Space, then, is a field of activity values. Interaction between activity centers is describable in terms of the dynamics of motion. For purposes of analysis we may set up an *instantaneous dynamics* which then becomes *our only true statics*. The hypothetical cessation of activity and the recording of the instantaneous activity tendencies which obtain at any particular instant constitute what we call statics. When we equilibrate the instantaneous tendencies by the introduction of suitable factors, then we have cases of ordinary statics as met with in the science of mechanics. These instantaneous activity tendencies may be conveniently considered as stresses in the interaction fields. A particle when unrestrained by the hypothetical cessation of interaction, upon the removal of the hypothetical restriction will be displaced in complete accord with the deduced instantaneous activity tendencies. It will move with definite velocity in that particular path which the interacting activity tendencies dictate. From our viewpoint statics is an instantaneous and consequently hypothetical or potential dynamics. Statics is dynamics viewed from the hypothetical limiting case of arrested motion or zero velocities. Statics is an analytical convenience by means of which the future behavior of a system may be predicted. Mathematics is neither statical nor dynamical. The mere insertion of the letter *V*, meaning velocity, and the letter *A*, indicating acceleration, does not create dynamics out of mathematics. If activity were not the essence of reality, then mathematics could not be a means of representing dynamical relations. Conversely, since activity is the essence of

reality, it follows that the introduction of instantaneous statics does not cause the cessation of dynamical activity. Therefore we may pass from instantaneous statical relations to dynamical relations, with the certainty that we are not violating the true principles of dynamical activity. Consequently if we have investigated the instantaneous, and therefore statical, conditions of a plane in space, we have correctly ascertained the conditions governing the subsequent motion of any particular system assigned to the plane. For these reasons we reserve the right to proceed in this manner whenever the requirement of a particular analysis demands the use of this method. Moreover, since space is a chart of potential or work values, the investigation of the instantaneous conditions in a field enables us to develop the dynamics of a system in conformity with what we may term the stress conditions of the field. By stress conditions in a field or plane we mean the instantaneous activity conditions tending to the production of motion. The curvilinear or rectilinear resultant arising from such an investigation constitutes the resultant path of motion of the system assigned to the field. The true relation between statics and dynamics is therefore emphasized in the Space-Time Potential. Since every relative point in space has a relative work value, our system is fundamentally dynamical. The dynamics of the Space-Time Potential is essentially Non-Newtonian.

94. Non-Newtonian Dynamics.

We retain in our Non-Newtonian Dynamics the fundamental relations pertaining to motion, force, and work. For reasons given later we abandon the Newtonian relation

$\left(\frac{1}{s^2}\right)$ and adopt its anti-differential, that is, $\int \frac{-ds}{s^2}$, because of its direct relation to the fundamental relations pertaining to motion, force, and work. Moreover, we substitute the anti-differential because of the fact that it makes possible a complete unification of statics, dynamics, atomic dynamics, ultra-atomic dynamics, thermodynamics, the theory of light and electricity. The innovation is justified not alone by the resulting unification and simplification, but

by the fact that our system becomes philosophically defensible and consistent. In our Non-Newtonian Dynamics we require no constants to bridge the discrepancies between ultra-atomic dynamics and the dynamics of material aggregates. The observed relations of physical astronomy are derived from the Newtonian relation by resorting to unjustifiable limitations. Without these unjustifiable limitations, Newton could not have derived the Keplerian Laws. Coulomb's relation is subject to the same criticism. The universality of the Newtonian relation must be abrogated whenever we desire to apply it to a definite system.

95. Critical Analysis of the Newtonian Relation.

The Newtonian deductions concerning planetary motion depend upon the fundamental assumption that the distance s between two centers (sun and earth, for example) varies; then it is shown that the type of the orbits (conic sections) depends upon the special form of the expression for velocity. Now if the distance s varies in a given time, then naturally the velocity must vary. Since a mass variation is excluded in the assumption upon alleged physical grounds, it is maintained that the phenomenon is solely due to a distance variation. The masses of both the earth and the sun are supposed to remain constant, hence the distance variation is the only condition which affects the problem. If the distance s did not vary, the application of the differential calculus would produce a result equal to zero, for the differential coefficient of a constant is zero. The retort is that the distance s actually does vary, hence we have the right to apply the differential calculus to the problem. We admit that astronomical observations show conclusively that the variation in the distance s takes place, but we contend that the *calculus creates no physical reason* for the variation. All that we get out of the procedure is the fact that if there is a variation in the distance s , then there is a variation in the velocity of the planetary body and the type of the orbit depends upon the nature of the velocity variation. This in itself is nothing astounding. A layman, not conversant with the calculus, would arrive at the same conclusion. The crux of the problem is in the variation of s , the distance between the central body and its satellite. The following

question is here pertinent: Is the change in velocity of the satellite due to a change in the distance s , or is the change in the distance s due to a change in the velocity of the satellite? It may be replied that our question is a mere trick of sophistry and that the fact is that the satellite arrives within the sphere of influence of the central body with a definite initial velocity. After this arrival, the governing influence of the central body begins. We maintain that this reply evades the question. Moreover, we hold that the question is pertinent. The reply suggests another question. Where does the sphere of influence of the central body begin, and when may we state that the satellite has "arrived"? According to Newton, the gravitational effect extends throughout the universe *ad infinitum*. The line of demarcation which bounds the sphere of influence of the central body must consequently be coincident with the resultant locus arising from the mutual action between the central body and the remaining totality of the universe. It is assumed that the mass of the central body remains constant. Therefore the behavior of the satellite when it reaches this line of demarcation must be governed by the conditions which pertain to the remaining totality of the universe. The mutual action between the central body and the rest of the universe defines the locus of demarcation, but since the central mass is constant the subsequent behavior of the satellite depends upon the rest of the universe. It is evident that the governing conditions in the rest of the cosmos may be of a constant or a variable nature. If they are constant, then the locus resultant must depict a path conformable with a constant velocity, that is, a circle. If the governing conditions in the rest of the physical universe persist in variability, then the locus will be a curve which conforms with this variation. If the variation is pulsating and periodic, then the locus may be a conic of the elliptic form. The variation in the rest of the universe may involve changes in position or mass magnitude, or both. The initiation of this variation cannot be ascribed to anything or any source within the system itself. It must be due to an agency outside of the system. Consequently the Newtonian implications force us to the concept of a Transcendent God. If resort is made to an infinite time, then the variations in

the rest of the universe would long ago have ceased. The cosmic system would then have had an infinite time within which to equilibrate itself. The clock of the universe cannot wind itself, for there is no perpetual motion extant within the universe. Continuous activity ultimately depends upon the continuous maintenance of a potential difference within the physical universe. We have already proved that God only can maintain this potential difference. Returning to the question concerning the relation between a change in the distance s and the change in velocity, we realize fully that the form of the question is repulsive to the physicist. He will maintain that the change in velocity inevitably involves a change in s , the distance, and conversely that a change or variation in the distance s with equal certainty involves a variation in the velocity. We hold that this contention of the physicist is a sophism *par excellence*. Most assuredly the contention is true because it is a mere statement of identity. Nothing is contained in the one idea that is not already contained in the other. If the distance s varies, then the velocity varies; and if the velocity varies, then s , the distance, varies. The intent of our question is to discover the nature of the potent condition which is capable of bringing about a change or variation in either the distance s or the velocity of the satellite. No one will maintain that the distance s is a potent agency which is capable of changing itself to something other than itself. It follows that the change in the distance s is a mere accompaniment, though inevitable, of the variation in the velocity. We have seen that the masses of the central body and the satellite have nothing to do with the variation because they are constant. Be it understood that this is the Newtonian position. From our viewpoint these two masses interact with the rest of the universe, and therefore, whether constant or variable, they are not impotent factors in the phenomena. Following the Newtonian assumptions to their inevitable conclusion, we must admit that the variation in the velocity of the satellite is due to the rest of the universe and not to the masses considered. Newton's development of the Keplerian Laws, however, ignores the rest of the universe. Only the grossly biased and obstinate worshipers of mathematical legerdemain can persist in the contention that the

Newtonian procedure is sound and justifiable. The Newtonian implications force us to admit interaction. If we are to develop the planetary orbits consistently we must not ignore the great remainder of the universe for the sake of two comparatively insignificant bodies like the sun and the earth. Consistent analysis therefore demands that we attack the problems of physical astronomy by introducing a two-directional stress system into the plane of the orbit. A full account of minor perturbations requires a three-directional system. The plane of the orbit is regarded as of unlimited extent, therefore all the activity factors within this plane are included in the analysis. For circular orbits we consider the stress components as being equal in magnitude. For a two-directional system of unequal intensities the orbits will be conic sections other than the circle. The relative magnitude of the stress intensities controls the type of the orbit. When we proceed in this manner the expression for the orbit will involve the stress intensities, and therefore type dependence will be directly related in our expression to these intensities. In other words, our expression will include a genuine physical activity relation capable of accounting for the modifications of the orbits. We have seen that the mere inclusion of the velocity in the Newtonian expression constitutes no real physical reason for these modifications. The ultimate maintenance of the stress intensities depends upon the Being of God. For us science is a record of the facts of the physical universe, ascertained experimentally and representing, in the final analysis, the active thought of God.

96. Further Difficulties of the Newtonian Contention.

Since the time of the battle royal between the Newtonians and the Cartesians, the Newtonian formula has reigned supreme in the scientific world. The Newtonian formula, possessing the quality of simplicity when contrasted with the Cartesian vortex motion in a frictionless fluid, beat down opposition by the sheer force of its simplicity. Be it noted, however, that the Cartesian development gives the Keplerian Laws as a mathematical consequence with even greater ease than the Newtonian formula. We mention this fact in order to show that the Newtonian formula is not

the only method whereby the Keplerian relations may be developed. This misconception seems to be general with those who are not familiar with the history of physical mathematics. For this reason the finality of the Newtonian position has been accepted as practically self-evident. Since the pendulum of thought in the time of Newton was swinging away from the fluid motion, the Newtonian formula gained the ascendancy. The writer bears the most profound reverence for the great work which Newton gave to the world. Not very many years ago he was one of those who ardently maintained that the Newtonian Law of Gravitation was the one generalization in the history of scientific advancement which would withstand the attack of future generations. The Newtonian concept gave him such profound satisfaction that he cherished hopes that it was an expression which would ultimately explain all phenomena of interaction, including in its domain the activities of molecules, atoms, and electrons as known to chemistry, electrochemistry and electricity. The electrical law that attractions and repulsions are commensurate with the product of the charges and inversely commensurate with the square of the distance between them, seemed to him to be but a further extension of the Newtonian generalization which dealt only with attractions. At the seventh general meeting of the American Electrochemical Society, held at Boston, April 25, 26 and 27, 1905, he read a paper entitled "The Interdependence of the Atomic Weights and the Electrochemical Equivalents" (*Transactions of the American Electrochemical Society*), in which he calculated the charge on an electron from the standpoint of compressive work done on a spherical shell. Not being able to reconcile his own view with that of physics, which maintained that the Newtonian expression is inapplicable to molecular, atomic, and electronic conditions, he endeavored to bridge the gap between gravitation and electricity before giving the above-mentioned article its final form. Failing in this attempt at absolute unification of the two phenomena under the law of inverse squares, he abandoned the solution, for the time being, with this statement: "Gravitational and electrical mass may then be regarded as the two aspects in which mass manifests itself to us. On the one hand we have at-

tractions, kinetic energy, absorption, and integration; on the other hand we have repulsions, potential energy, self-conservation, and differentiation; yet these are merely the two modes in which actual mass interaction takes place."

The reason for the failure lay in his absolute confidence in the Newtonian law of gravitation which involves the product of the masses and the inverse square of the distance. If we assume that, whatever may be the final form of the expression which relates activities associated with mass aggregates, that same expression is also capable of describing the magnitude of the activities pertaining to the ultimate constituent mass particles, we are within the realm of the reasonable and rational. If the counter-assertion is made that the Newtonian law of inverse squares holds for mass aggregates, but does not hold for the mass constituents, this in itself is not a sufficient reason for abandoning the above-outlined postulate, because the law of inverse squares may not be a correct statement of the magnitude of the involved activities. Consequently we propose to retain this postulate, reserving its proof for a more appropriate place in our discussion.

We shall now point out further anomalies in the Newtonian expression. In nature mass increase is produced by addition—and not by multiplication, as in the gravitational formula—and the resultant associated activities are sums and not products. Mechanics, dealing with force relations, finds them additive in their resultant effects and not commensurate with the result obtained by multiplication. In this respect, therefore, the Newtonian formula places itself in flagrant opposition to observed facts. Furthermore, the formula asserts that the force depends not only upon the product of the masses, but upon an inverse ratio of the second power of the distance. This latter assumption no doubt had its origin in the geometric spatial analogy of a system of concentric shells having the center of force emanation as their common center. What interpretation, then, shall be given to the term "force"? If the emanating force is a radiating, flowing substance, then as a definite quantity spreads itself uniformly over the surface of successive concentric spherical shells, it is reasonable to suppose that the quantity of the emanating fluid force per unit of area will stand in an inverse ratio to the squares of the radii of successive shells because their areas increase as the squares of the respective radii. This involves us at once in a number of difficulties. In the first place, the motion of the emanating fluid force must be explained. This would necessitate the existence, at the center of emanation, of an auxiliary repellent force capable of sending the fluid force outward in radial directions. Secondly, what becomes of the diffused emanating fluid force if it is not fortunate enough to become attached to an object? Thirdly, is the supply of the emanating force, located at the center of emanation, unlimited in its available quantity? Fourthly, even if all these pertinent queries could be answered satisfactorily, granting that the fluid force has arrived at its goal, an object, by what mechanism can it produce motion in the body? Fifthly, what is to determine the direction of the imparted motion?

Returning to the conception of a system of spherical shells, we see that the Newtonian formula is analogous to the case of a fluid force dissipating itself over the surface of a sphere and consequently experiencing a decrease in its

density proportionate to the inverse squares of the radii of successive spheres. The intensity of the effect felt at a point on any successive shell is, according to this notion, directly proportional to the density of the fluid force upon the particular shell. No proof has ever been produced to substantiate this implication of the Newtonian conception. Force has never been shown to be an emanating fluid, and if this could be proved it would still be necessary to account for the fact that the fluid force makes no distinction between vacuum and matter. It dissipates itself over the entire spherical surface with mathematical precision, irrespective of the presence or absence of an object in its path. The object receives that portion of the force which lies within its own vectorial cone, while empty spaces receive the great preponderating remainder. What does empty space do with this remainder? Many other equally pertinent questions might be asked, but space does not permit.

97. The Universality of the Inverse First Power Variation.

Distance as an obstacle to the transmission of force, is another implication in the Newtonian assumption. To the writer's mind it seems more rational to assume that distance is merely a spatial symbol by which we are informed in regard to the relative magnitude of their combined activity in conjunction with all other active influences. In other words, distance is not an obstacle to action, but a sense measure of the inner relation of things existing in an interacting unitary system. Consequently we maintain that no reason can be found why this inner relation or affinity must be expressed as an inverse function of the second power of the distance. If we admit—as we must—that distance is a perceptual means of depicting the intensity of phenomenal relations, it does not follow that the square of the distance is a relative measure of the mutual effect. It is far more rational to suppose that the perceptual symbol is strictly proportionate to the relative effects made known through it; and consequently distance itself, expressed in its inverse first power, must be the ultimate measure of physical activity relationships. It may be asserted that this is mere speculation and that facts prove the *inverse square hypothesis*.

We maintain that the testimony of mechanics, the testimony of thermodynamics, and the testimony of electrochemistry bear out the contention for the inverse first power hypothesis. The subsequent portions of this discussion will be devoted to the proof of this assertion.

98. The Meagre Evidence Serving as the Basis of the Newtonian Relation.

It is maintained that physical astronomy is impossible without recourse to the Newtonian formula. Furthermore, it is contended that this formula is an absolute essential to the science of physics. May we inquire, what are these facts that constitute the living witnesses which testify to the validity of the Newtonian formula? In reply you will refer to the Newtonian inference that a central force varying inversely as the square of the distance to the earth and directly as the product of the sun's and earth's masses constitutes a complete causal explanation of Kepler's three laws. The amount of the moon's deflection toward the earth will be cited as another verification of the Newtonian tenet for the reason that the amount of this deflection can be calculated by the Newtonian formula. The phenomena of the tides will be mentioned as substantial evidence. The experiments of Cavendish, Cornu, Wilsing, Boys, and others, upon the deflection of masses under the gravitational influence will be used as further corroborative proofs. The fact remains, however, that all these experiments, because of their lack of precision, merely prove that a type of influence or interaction between bodies exists to which science has applied the name gravitation. Even hasty reflection will convince everyone of the difficulty of securing accurate data concerning the phenomena of the tides. The same is true of the other cases cited. Therefore such cases do not suffice to establish the correctness of a formula. Where precision is possible, the mass-product relation of Newton cannot be established. In such cases mass interactions are proportionate to the additive mass values and not to their products. Moreover, the spans between equilibrated masses are related in accordance with the inverse linear function of the first and not the second degree.

99. The Planetary Orbits According to the Space-Time Potential.

The errors in the Newtonian assumption have been clearly pointed out in the preceding. If results are obtained, in conformity with fact, from erroneous premises, then it follows that the *modus operandi* of obtaining these results must also be in error. In other words, two compensating errors have been introduced into the procedure. This bears out our contention that the Newtonian formula itself is in error.

The writer has developed the Keplerian relations from premises which are in complete accord with the principle of universal interaction hereinbefore set forth. Newton himself maintained the universality of gravitational interaction, but abandoned it in his test application to the orbital motions of the planets. In this way an apparent substantiation of his erroneous formula was secured. For the sake of the general reader we content ourselves here with a statement of the premises and the significance of the conclusions derived by the mathematical analysis.

Our development of the orbital equation is based primarily upon the fact that space is a sense chart of position values in such a manner that the location of a thing in space is determined by the directional intensity of the interaction at the particular position. For purposes of analysis we confine ourselves to a limited portion of this space. We further confine ourselves to any convenient plane *A* in space whose extension we limit by four lines. The plane *A*, thus bounded, is assumed to be subjected to interaction activity intensities in accordance with our fundamental principle. In a mathematical analysis it is convenient to consider definite components of the activity intensities. The writer has developed the following expression for the path of a body free to move in a plane *A* subjected to the before-mentioned activity conditions:

$$\frac{x^2}{F_x^2} + \frac{y^2}{F_y^2} = 1.$$

In this expression *x* and *y* are the coördinates of any point in the orbital curve, and *F_x* and *F_y* are the resultant activity intensities. This expression is the equation of a

conic section. In the form given it represents an ellipse. This equation differs in a marked manner from the Newtonian expression in that it contains a genuine physical basis for the types of the orbits. The truth of this assertion is apparent from an investigation of the expression itself, which shows that the type of the orbit depends upon the relative magnitude of the activity factors F_x and F_y . If these factors are equal to each other, the conic becomes a circle. If they are unequal in magnitude, the curve is an ellipse which tends toward a parabola when the ratio of their intensities approaches an infinite value. Conversely, if the orbit is an ellipse, the activity factors prevailing in the plane of the orbit are unequal in magnitude. For negative values of F_y^2 the curve becomes an hyperbola.

An exhaustive investigation of a material system interacting according to the tenets of the Space-Time Potential involves a reference to a three-directional system of coördinate axes. The space of sense is most conveniently regarded as a triply extended manifold. The Newtonian relation is derived from a one-directional vectorial system which regards the sun as a central force. The one-directional attraction between the sun and the earth is, according to Newton, a complete and sufficient reason for the earth's orbit type. We cannot agree with this convenient simplification for the reason that any finite portion of a plane A in space must be under the influence of a two-directional activity system. In this manner only are we able to include all the activity factors within the plane beyond the confines of the finite portion considered. By referring the finite portion of the plane, as the writer has done in his development, to an X and Y axis, all activity factors in the plane will be either above or below the X axis, and to the left or the right of the Y axis. In this manner only can we conform with the requirement that the interaction be universal. Newton's development fails utterly in conforming with this requirement, which is the most important part of his own enunciation.

The writer has developed the Keplerian relations by using the well-known facts of dynamics without resorting to the erroneous Newtonian central mass attraction idea and the

inverse square hypothesis. In these developments the author has adhered to the basic principle that the body which is free to move in the plane A is actuated by the activity factors F_x and F_y .

These developments, in addition to their intrinsic interest, serve to demonstrate the fact that our basic thesis of interaction is capable of constructive application resulting in relations which conform with observed facts. In this manner we remove the possibility of substantiating the charge that our work is destructive and not constructive.—See Appendix A.

100. The Obliquity of the Ecliptic Points to a Third Directional Activity Factor.

The inclination of the earth's axis to the plane of its orbit shows conclusively that a third activity factor influences the system. Since the obliquity of the ecliptic—that is, the angle between the plane of the ecliptic and the earth's equatorial plane—is about $23^\circ 27' 8''$, the angle which the earth's axis makes with the ecliptic is about $66^\circ 32' 52''$. This angle is practically constant during the earth's elliptical motion in the plane of the ecliptic. Since the earth's semi-diameter (according to Bessel) is 20,923,597 feet, the distance h along a normal to the plane of the ecliptic from the most remote point of the earth's equatorial circumference is 8,327,260 feet. During one complete revolution of the earth about its axis this point traverses through a total normal distance $= 4h$ in the time 23 hours, 56 minutes, and 4 seconds $= 86,164$ seconds. For the distance h the time is 21,541 seconds. This corresponds to an acceleration $a = 0.035892$ feet per second per second along the normal to the ecliptic, since $a = \frac{2h}{t^2}$. It is therefore clear that the obliquity of the ecliptic cannot be maintained without the continuous activity of a third directional activity factor.

101. Note on the Discrepancy Between the Newtonian Relation and Dynamics.

The Newtonian relation states that gravitational attraction varies directly with the product of the masses m and

M , and inversely with the square of the distance s between them; that is, G (the gravitational attraction) varies with

$$\frac{mM}{s^2}.$$

If we employ the fundamental and experimentally demonstrable laws of motion, force, and work which form the very foundation of dynamics, then a radically different expression results which involves the sum of the masses and the distance to the inverse first power. The truth of the laws of dynamics has been established by an overwhelming array of experimental facts. For this and other reasons already stated the physico-mathematical developments of the Space-Time Potential are Non-Newtonian. See Appendix B.

CHAPTER VII

SOME APPLICATIONS OF THE SPACE-TIME POTENTIAL.

102. The Basic Functions of the Space-Time Potential.

We have already shown that the laws of motion of planetary bodies may be derived from the principle of universal interaction in a unitary system as set forth in the Space-Time Potential. Without entering into the details of the actual mathematical analysis, we shall briefly outline some further applications of the system.

We have pointed out the fact that the Newtonian inverse square variation hypothesis does not agree with an overwhelming array of easily ascertained experimental facts. Dynamics and mechanics, *in toto*, contradict the Newtonian tenet. Moreover, the Newtonian hypothesis fails utterly to account for ultra-atomic energies. Whatever the laws may be which pertain to the ultimate primordial particle, these laws also hold, without modification, for the aggregates of these particles. An increase or decrease in the mere number of these particles in no way affects their ultimate nature. Sense perception tells a true story of the relative intensity of the interaction between these particles and their aggregates. Therefore distance to the first power, and not to the second power as held by Newton, is the true measure of the relativity of the interaction. In ultra-atomic activities the Newtonian relation must be augmented by arbitrarily chosen constants in order to account for the developed intensities. Sense perception tells us that when two particles are in close proximity, the interaction is greater than when they are separated by a greater distance. The direct testimony of sense perception introduces two facts: first, an inverse relation; and, second, an actual distance which means distance to the first power. Newton's principal claim for the justification of his inverse second power relation is based upon the alleged agreement with the requirements of planetary motion. The errors involved in this contention have been set forth. The

writer has shown that the planetary relations can be developed, without the use of the Newtonian relation, from premises which agree with fact and which were held by Newton himself only to be abandoned when he attempted a direct application.

The basic tenet of the Space-Time Potential is that the intensity of universal interaction varies inversely with the first power of the distance intervening between any two interacting particles. By using this principle a reconciliation, without the use of arbitrary constants, is effected between celestial mechanics, dynamics, statics, thermodynamics, molecular physics, electricity, and ultra-atomic activities. Our basic tenet may be stated definitely as follows: the intensity of interaction I_s for any variable intervening distance s between any two activity factors A and B varies inversely with the distance s between them. From this statement follows that

$$I_s = k \left(\frac{1}{s} \right),$$

where k is a constant which can be determined experimentally. By selecting proper units the constant k may be made equal to unity, and then the expression is at once recognized as the equation of the hyperbola. This relation constitutes the *primary or hyperbolic function* of the Space-Time Potential.

By integrating this primary function we obtain an expression for the work W done in the displacement of an activity factor from some initial position to a final position. In order to accomplish this summation or integration by the calculus the so-called differential of the variable must be introduced. In this way we obtain the following relation:

$$W = \int I_s \cdot ds = \int k \left(\frac{1}{s} \right) ds = k \cdot \log s.$$

The latter expression constitutes the secondary or logarithmic function of the Space-Time Potential.

Be it noted that both of these basic functions involve the inverse first power of the distance. In the following paragraphs we shall give some of the direct applications of these functions.

103. Some Typical Cases of the Primary or Hyperbolic Functions.

Boyle's Law of Isothermal Expansion of Gases, in which the temperature remains constant during expansion, states that the product of the pressure p and the volume v is equal to a constant c , that is,

$$pv = c \text{ and } p = c\left(\frac{1}{v}\right)$$

evidently comes under the primary or hyperbolic function. It is evident that the volume is a function of the distance s between the gas particles. For any two given particles the variation is a function of the inverse first power of the distance s . The resulting volume is due to this type of interactional activity in a three-dimensional manifold.

In the field of electrochemistry we find the inverse first power relation governing the activities. Mass dissociation in an electrolytic cell due to the action of definite current intensities may be represented by

$$M = h\left(\frac{1}{r}\right),$$

where M is the liberated mass in grams, r is the current in ampere-hours, and h is a constant. The above expression may be reduced to its primitive form:

$$(Ma)s = F.s = C, \text{ and } F = C\left(\frac{1}{s}\right)$$

In this latter form it is clear that electric dissociation comes under the primary or hyperbolic function. It is worthy of note that, by suitable transformations, the distance factor may be made to appear as a direct instead of an inverse variation. However, in the former case the expression will be indicative primarily of something other than a pure activity intensity.

The real significance of the charge e exhibited by an electron and an ion is seen from the expression—

$$mr = e, \text{ a constant,}$$

where r' is the C. G. S. electrostatic units per unit of valence necessary to liberate one gram of an ion, and m is the mass of the ion using the gram as the unit of mass.

From the above expression it is apparent that electrical relations are of the same order as the volume-pressure

relation which pertains to gases. In other words, the masses of the ions are related to the electrical intensities or charges in the same manner as the volume of a gas is related to the applied pressure. Herein we have the real meaning of the constancy of the charge e which is used so frequently in modern electrophysics.

104. Essential Features of the Secondary or Logarithmic Function.

According to the Space-Time Potential, interaction is unfolded in time upon that potential chart of work values which we call space. Since space and time are relativities of the first order, it follows that the work values themselves have only relative significance. The relative relations between the work values in the most minute portion of space are deducible from the same fundamental function which serves to interpret these relations in a space of unlimited extent. The writer has shown that the secondary or logarithmic function may be used to construct a space chart of work values. When this is done we find that this function contains within itself the story of two worlds: the *microcosm*, the small world of positons, energons, electrons, and atoms; and the *macrocosm*, the great world of molecules, bodies, and planets. When the secondary function,

$$W = F(s) = (Ma)s = \int I_s \cdot ds = \int k\left(\frac{1}{s}\right)ds = k \cdot \log_e s,$$

is plotted from some suitable point as a center, preferably the point which causes $(\log_e s)$ to equal zero, we obtain a series of concentric loci which pertain to definite potential work values. For example, if we begin with zero and take any series of n numbers like the following: 0, 0.01, 0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, 0.90, 1.00, $1.111/9$, 1.25, 1.43, 1.67, 2.00, 2.50, 3.33, 5.00, 10.00, 20.00, 100.00 . . . etc. . . . n , we find that this group of numbers divides itself into two systems of positive and negative work loci about the number 1.00 as the neutral norm of the systems. Suppose, now, that we adopt a convenient distance unit (centimeter or inch) and plot these values as distances, beginning with zero, along the same straight line,

then we have established a condition which is replete with unlimited physico-mathematical possibilities. The scope and intent of this work prohibit a detailed exposition of the writer's investigations in this field. We have previously refuted materialism and we have shown that a consistent and true interpretative science must be based upon philosophy and religion, for the reason that the isolation of speculative science from philosophy and metaphysics invariably results in a narrow view of the cosmos which therefore redounds with inconsistencies. In this constructive portion of our work we show that consistent scientific developments possessing unlimited unifying potencies follow directly from our broader view of reality. We are forced to confine ourselves to a brief statement of some of the particularly significant developments.

Returning to the consideration of the n numbers, plotted as distances along the same right line from an initial origin or zero point, let us divide the group of numbers into two sub-groups formed about the point corresponding to the number one, to which the writer has given the name "*change point*" for the obvious reason that the work values change their signs in passing through this point. Beginning with the change point (1), let us designate all numbers greater than 1 as group G and all values of n less than 1 as group L . Group G then is composed of all values of n from one (1) to infinity (∞), and group L is composed of all values of n from one (1) to zero (0). The author has shown that for all values of n in group G the work value or work constants are positive (+), and for all values of n in group L the work constants are negative (-). Moreover, he has proved that for any particular positive work constant (+W) calculated from a given value of n in group G , there corresponds an equal negative work constant (-W) which may be calculated from the value ($\frac{1}{n}$), that is the reciprocal of n in the group L . The work done in displacement from the change point 1 to any point n is given by the relation

$$W = k \left\{ \log_{\epsilon} n - \log_{\epsilon} 1 \right\} = k \cdot \log_{\epsilon} \left\{ \frac{n}{1} \right\}.$$

Similarly, the work of displacement from point m to point n is found from the expression

$$W = k \left\{ \log_e n - \log_e m \right\} = k \cdot \log_e \left\{ \frac{n}{m} \right\}.$$

Moreover, the work done in displacement from the change point 1 to any point $\left(\frac{1}{n}\right)$ in group L is expressed by

$$W = k \left\{ \log_e 1 - \log_e \left(\frac{1}{n} \right) \right\} = k \cdot \log_e \left\{ \frac{1}{\frac{1}{n}} \right\} = k \cdot \log_e n.$$

To illustrate by specific values, we find that for a value of $n=100$, $W=+4.605$, and for a value $\left(\frac{1}{n}\right)=\frac{1}{100}=0.01$ we find that $W=-4.605$. Similarly, for $n=1.25$, $W=+0.223$, and for $\left(\frac{1}{n}\right)=\frac{1}{1.25}=0.80$, $W=-0.223$. See Appendix C.

If we let s_n be the distance from the change point 1 to any point n in the group or system G , and $s_{\#}$ the corresponding distance from the change point to the point $\#$ in the system L , then we readily observe that

$$s_n = (n-1), \text{ and } s_{\#} = \frac{(n-1)}{n}.$$

Thus, for $n=2.5$, $s_n=(n-1)=(2.5-1.0)=1.5$, and

$$\text{for } \left(\frac{1}{n}\right)=\frac{1}{2.5}=0.4, s_{\#}=\frac{(n-1)}{n}=\frac{(2.5-1)}{2.5}=0.60.$$

To construct the two corresponding work loci we lay off a distance $s_n=1.5$ unit along a straight line to the right of an arbitrarily chosen change point, and to the left of the change point along the same line we lay off a distance $s_{\#}=0.60$ unit.

The value $n=2.5$ corresponds to $s_n=1.5$, and for $\left(\frac{1}{n}\right)=0.4$, $s_{\#}=0.60$. The work constant W_n (corresponding to the value $n=\log_e n=\log_e 2.5=\text{hyperbolic logarithm of } 2.5=+0.916$). Similarly, the work constant $W_{\#}$ (corresponding to the value $\left(\frac{1}{n}\right)=\log_e \left(\frac{1}{n}\right)=\log_e 0.4=\text{hyperbolic logarithm of } 0.4=-0.916$).

The corresponding force constants are:

$$F_n = \frac{W_n}{s_n} = \frac{+0.916}{1.5} = +0.610\frac{2}{3}, \text{ and } F_{\#} = \frac{W_{\#}}{s_{\#}} = \frac{-0.916}{0.6} = -1.52\frac{2}{3}.$$

Work or potential loci may be plotted in any given plane in space concentrically about the change point as a radial center. Interacting mass-acceleration ($M.a$) aggregates or kerns group themselves in complete conformity with the force loci of their common plane. The particular spatial juxtaposition of the activity kerns is a direct consequence of the innate character of reality and not of the coercion of space. Similarly, the ordered flow of change is due to the innate intent of reality and not to a coercive influence of time regarded as an activity agent. In order to clarify the meaning of the above statements let us consider the two mass-acceleration kerns

$$F_n = M_n \cdot a_n \text{ and } F_* = M_* \cdot a_*$$

The Universal Law of Interaction exemplified in our secondary or logarithmic function is substantiated by all known experimental facts. This law demands that during interaction the two kerns F_n and F_* be continuously located in the same straight line, on opposite sides of their common change point, and in loci whose work or potential constants are equal in magnitude but opposite in sign. If the two kerns be in rotation they will continue to rotate along loci of equal potential about the change point as a common center unless this form of activity be modified by the advent of extraneous influences. We give the name "normal line" to that straight line which passes through the change point and upon which the two kerns are located. If the kern F_n is displaced away from the change point along the normal line to a locus of higher potential, then the kern F_* is simultaneously displaced in the opposite direction, to a locus of the same potential but opposite in sign. During displacement along the normal line both kerns undergo a change in magnitude which conforms with the constants of the traversed loci. Herein, then, we find a valid physical reason for the Kaufmann effect. When a system is in rotation in accordance with the mandates of the universal law of interaction, we say that it is in a condition of *dynamic equilibrium*, in contradistinction to the well known terrestrial condition of *static equilibrium*. If the kerns be great aggregates, as in the case of the sun and the earth, then the change point may be found within the

confines of the greater kern. The resulting orbits are loci of equal potential. The type of the orbit is a resultant of the complexity of the interaction. It should now be clear that distance is not a barrier to action, but a measure of its relativity. We may now readily picture the relations between the two kerns F_n and F_{\pm} . For a value of $n = 2.5$ we must locate $F_n = M_n a_n = 0.610 \frac{2}{3}$ along the normal line at a distance $s_n = 1.5$ unit. In the oposite direction and at a distance $s_{\pm} = 0.60$ unit we must locate the other kern $F_{\pm} = M_{\pm} a_{\pm} = 1.52 \frac{2}{3}$. If the system be in rotation and uninfluenced by extraneous factors (a purely theoretical case), then the kerns will rotate about the change point in concentric circular orbits whose radii are designated by the values of s_n and s_{\pm} respectively.

The product of the kern magnitude F_n by its distance s_n is equal to the product of F_{\pm} by s_{\pm} . This relation is of the same type as that well-known relation in statistic which pertains to the lever. A notable difference is the fact that the accelerations are different in magnitude. This is evident if we write the above statement in terms of mass and acceleration as follows:

$$(M_n \cdot a_n) s_n = (M_{\pm} \cdot a_{\pm}) s_{\pm}.$$

The writer has shown that the ratio between the two accelerations a_n and a_{\pm} is equal to the value n for all values of n greater than $1.11\frac{1}{3}$, and consequently for all values of $\left(\frac{1}{n}\right)$ less than 0.90. If we make the two accelerations in the above expression equal, we can at once deduce the law of the lever, which is the most important principle in mechanics and statics.

Since n in the above is greater than $1.11\frac{1}{3}$, $\frac{a_n}{a_{\pm}} = n$ and $a_{\pm} = \frac{a_n}{n}$. The following is self-evident:

$(M_n \cdot a_n) s_n = n \left\{ M_n \left(\frac{a_n}{n} \right) \right\} s_n = n \{ M_n \cdot a_{\pm} \} s_n = \{ M_{\pm} \cdot a_{\pm} \} s_{\pm}$, and therefore it follows that

$$(M_n) n \cdot s_n = (M_{\pm}) s_{\pm}.$$

This expression is of the same order as the well-known law of the lever. That it is correct in value as well as form may

be shown by reducing it to an identity by substituting the following values:

$$M_{\frac{1}{n}} = n^2(M_n), \text{ and } \frac{s_n}{s_{\frac{1}{n}}} = n,$$

which the writer has shown to be true for all values of n greater than $1.11\frac{1}{3}$.

In the terrestrial gravitation constant of acceleration g , we find a common case of equalized acceleration which modifies the general expression, as shown above, into the form expressed by the law of the lever. For the case of the lever the change point becomes the fulcrum in reference to which the arm of $M_{\frac{1}{n}}$ is $s_{\frac{1}{n}}$ and the arm of M_n is ns_n . The following is noteworthy:

$$\frac{M_{\frac{1}{n}}}{M_n} = \frac{n \cdot s_n}{s_{\frac{1}{n}}} = n^2.$$

By this relation in the well-known law of the lever is linked to the "genital number" n of the Space-Time Potential.

A simple numerical example will serve to illustrate the relation between dynamic and static equilibrium outlined above.

Let the genital number $n = 2.5$, as above. For this value of n the work constants are $+ W_n = + 0.916$ and $- W_{\frac{1}{n}} = - 0.916$. The corresponding force constants are $F_n = + 0.610\%$ and $F_{\frac{1}{n}} = - 1.52\%$.

CASE I. DYNAMIC EQUILIBRIUM

The mass $M_n = \text{unity}$ is located on the work locus $+ W_n$ at a distance $s_n = 1.5$ unit from the change point.

The mass $M_{\frac{1}{n}} = n^2 (M_n) = (2.5)^2 (1.0) = 6.25$ units is located on the work locus $- W_{\frac{1}{n}}$ at a distance $s_{\frac{1}{n}} = 0.60$ unit from, but on the other side of, the change point, all three points being on the normal line. The following relation holds:

$$F_n \cdot s_n = F_{\frac{1}{n}} \cdot s_{\frac{1}{n}} \text{ and } + 0.610\% (1.5) = 1.52\% (-0.6) \\ = W_{\frac{1}{n}} = 0.916.$$

CASE II. STATIC EQUILIBRIUM

This is the case of the ordinary lever.

The mass $M_n = \text{unity}$ is located at a distance $n(s_n) =$

$2.5 \cdot (1.5) = 3.75$ units from the change point, which now constitutes the fulcrum of the lever. The Mass $M_{\frac{1}{n}} = 6.25$ units, as previously, remains located as in Case I. Then we have the following:

$$(M_n) n \cdot s_n = \left(M_{\frac{1}{n}}\right) \frac{s_{\frac{1}{n}}}{n}$$

$$\text{and } (1.0) \cdot (2.5) \cdot (1.5) = (6.25) \cdot (0.60) = 3.75.$$

It is evident that for $M_n = \text{unity}$ the constant for this system is $n (s_n)$.

Although the scope of the main portion of this work prohibits a mathematical treatment, nevertheless it would be unfortunate to omit the simple relations which unfold themselves as a consequence of the philosophical contemplation of the physical universe.

105. Macrocosmic Relations.

Let

$n = \text{the genital number,}$

$W_n = \text{the work done from the change point 1 to the point } n,$

$W_{\frac{1}{n}} = \text{the work done from the change point 1 to the point } (\frac{1}{n})$ (this work is the same, irrespective of direction),

$t_n = \text{time of translation through distance } s_n,$

$t_{\frac{1}{n}} = \text{time of translation through distance } s_{\frac{1}{n}},$

then, for values of n greater than $1.11\frac{1}{3}$ and for $(\frac{1}{n})$ less than 0.90, the following relations, derived from the secondary or logarithmic function, hold good:

$W_n = W_{\frac{1}{n}} = \text{the hyperbolic logarithm of the genital number } n;$

$$t_n = t_{\frac{1}{n}}; s_n = (n - 1); s_{\frac{1}{n}} = \left(1 - \frac{1}{n}\right) = \frac{(n - 1)}{n};$$

$$\frac{s_n}{s_{\frac{1}{n}}} = \frac{v_n}{v_{\frac{1}{n}}} = \frac{a_n}{a_{\frac{1}{n}}} = \frac{M_{\frac{1}{n}} \cdot a_{\frac{1}{n}}}{M_n \cdot a_n} = n; \frac{M_{\frac{1}{n}}}{M_n} = n^2;$$

$$W_n = (M_n \cdot a_n) s_n = W_{\frac{1}{n}} = (M_{\frac{1}{n}} \cdot a_{\frac{1}{n}}) s_{\frac{1}{n}}; F_n = \frac{W_n}{s_n}; F_{\frac{1}{n}} = \frac{W_{\frac{1}{n}}}{s_{\frac{1}{n}}}.$$

These relations pertain to celestial mechanics and molecular physics. In conjunction with the ordinary laws of motion, and by suitable modifications to conform with ter-

restrial conditions, these relations constitute the fundamentals of macrocosmic mechanics. The resulting values receive their proper interpretation through the selection of suitable units.

106.—Microcosmic Relations

By means of the secondary or logarithmic function we may pass with precision from the macrocosm to the microcosm without resorting to constants, arbitrarily chosen, in order to reconcile the glaring discrepancies which arise in the old physics. For values of n less than $1.111\frac{1}{9}$ and of (\pm) greater than 0.90, the following relations, derived directly from the secondary or logarithmic functions, obtain:

$$W_n = W_{\frac{1}{n}}; t_n = t_{\frac{1}{n}}; s_n = s_{\frac{1}{n}}; v_n = v_{\frac{1}{n}}; a_n = a_{\frac{1}{n}}; M_n = M_{\frac{1}{n}}; M_n \cdot a_n = M_{\frac{1}{n}} \cdot a_{\frac{1}{n}}$$

Our secondary function takes us, without apology, into the world of atoms, positons, energons, and electrons. It is noteworthy that the orbital radii in the microcosm are equal for a given system derived from a particular genital number. We have seen that in the macrocosm they are unequal and that their ratio is expressed by n , the genital number.

107. Applications of These Relations.

Using the expression pertaining to motion in conjunction with the relations previously set forth, the writer has calculated the charge e exhibited by an electron. In these calculations the mass of the electron was assumed to be that which corresponds to a velocity $v = 3.0 \times 10^6$ centimeters per second = $\frac{1}{c}$ of the velocity of the light in air. For this velocity the mass of the electron is practically constant. The writer's calculated value of $e = 4.77 \times 10^{-10}$ C. G. S. electrostatic unit corresponds closely with the experimental values derived by H. A. Wilson ($e = 3.1 \times 10^{-10}$), J. J. Thomson ($e = 3.4 + 10^{-10}$) and R. A. Millikan (4.77×10^{-10}). See Appendices B and D.

An important fact was disclosed by these calculations. It became evident that the masses of ions and electrons are related to the electrical intensities in the same way that the volume of a gas is related to the applied pressure. This fact

constitutes another confirmation of the fundamental tenets of the Space-Time Potential.

The writer has employed the above fundamental relations in the calculation of the physical dimension of molecules. The method is free from the mathematical complexity of the prevalent methods. The writer's method consists briefly in the determination of the genital number n which corresponds to the decomposition voltage for any particular molecule. Thus in the case of the hydrochloric acid molecule, whose normal solution has a decomposition voltage of 1.31 volts = 0.0043666 C. G. S. electrostatic unit of potential difference, we find that the work constants equal 1.99322×10^{-19} . The distance s_* from the change point to the center of the hydrogen atom is found to be 2.47730×10^{-8} cm. Similarly, the distance s_{**} from the change point to the center of the chlorine atom is found to be 0.41755×10^{-8} cm. The distance center to center of the hydrogen and chlorine atoms is, then, the sum of these values; that is, 2.89485×10^{-8} centimeters. This result is in complete conformity with results derived by totally different and far less direct methods of investigation.

108. Theory of Relativity.

Were we asked to choose the most stupendous of the unlimited number of marvels and mysteries extant in the physical universe, we feel certain that no error would be committed if we selected the phenomenon of light. How a person of sound mind can remain a materialist after contemplating the infinite profundities involved in the phenomenon of light is beyond comprehension. That the world is far more than matter and chance should be evident to any person free from bias, after nothing more than a hasty survey of this most marvelous phenomenon. Not least of its many marvels is the extraordinary fact that the velocity of light (3×10^{10} centimeters per second) is a constant, irrespective of the velocity of the observer. If an observer travelled in an aeroplane, in the direction of the propagation of light, at the velocity of 100 miles per hour, then if it were possible to increase this velocity to 100,000 miles per hour the observed velocity of propagation of light would still remain the same. The broad interpretation of the experiments of

Michelson and others leads to this astounding conclusion. This fact forms the basic nucleus of the modern theory of relativity. H. A. Lorentz has attempted, with exceptional ingenuity, to derive a physical basis for the theory of relativity. Lorentz believes that an independent ether interacting in a compressional manner with electronic matter provides the desired physical basis for the principle of relativity. Poincaré has done much to further this view. We are at one with these investigators in their contention that the root of relativity is found in interaction, but we differ with them in their conclusion that the interaction factors are radically different in their ultimate nature. We find our physical justification for the principle of relativity in the *interaction between the concurrent and excitant masses* in accordance with the relations inherent in our primary and secondary functions. According to our view, the excitant mass (of sub-atomic magnitude), during its translatory progress through the concurrent system, composed of gyratory groups of energons, interacts therewith in a manner productive of those vibratory oscillations known generally as waves of light. Electric oscillations are of the same general order and are produced in a similar manner. For the phenomena of light and genital number $n = v$, the velocity of light (3×10^{10} centimeters per second). Letting the subscript n refer to the *excitant system* and the subscript $(\#)$ to the *concurrent system* and using the macrocosmic relations (paragraph 105), we have the following expressions on the basis of a unit of time:

$s_n = v_n = (n - 1) = (V - 1)$, for the excitant system, and

$$s_{\#} = v_{\#} = \frac{(n - 1)}{n} = \frac{(V - 1)}{V}, \text{ for the concurrent system.}$$

From this it follows that:

$$\frac{v_n}{v_{\#}} = V; (v_n + v_{\#}) = (s_n + s_{\#}) = \frac{(V^2 - 1)}{V} = \text{practically } V.$$

This means that the ratio of the velocity v_n of the excitant system to the velocity $v_{\#}$ of the concurrent system is always equal to the constant velocity V of light. Moreover, the total energized space, for a period of interaction equal to one second, is practically equal to the same constant V . The constancy of the velocity of light arises out of the relative

velocities of the excitant and the concurrent systems. In this fact we have a genuine physical basis for the principle of relativity. The present extent of our knowledge of physical facts indicates that the maximum value of the genital number n which obtains in the physical universe is $n = V = 3 \times 10^{10}$. That the velocity v_n of the electronic excitant system can never equal the value V is evident from the expression $v_n = (n - 1) = (V - 1)$. The velocity v_{\pm} of the concurrent system differs inappreciably from one centimeter per second or a little less than two feet per minute. The effect of so slight a translatory motion is negligible as far as terrestrial conditions are concerned. The distance K traversed by light in one second is the cosmic unit of distance. The writer has given the name "Kosmometer" to the distance $K = 3 \times 10^{10}$ centimeters. The Kaufmann effect finds its interpretation in the secondary function by making the *unit distance* from the change point to the origin of coördinates equal to $s_{\pm} = \frac{1}{2}K$. Velocities v plotted from the change point along the horizontal or X axis will then appear as fractions of the velocity V for the time unit one second. The work constant for any velocity v is then the vertical ordinate corresponding to the value $(v \div V)$ measured from the change point. By applying the fundamental relations of the secondary function to this system the writer has developed the following expression for the force (mass-acceleration) kern (F_{\pm}).

$$F_{\pm} = \frac{\log_e \left\{ 1 - \frac{v}{V} \right\}}{\left\{ \frac{v}{V} \right\}}.$$

That the variation of the velocity v has practically no effect upon the value of F_{\pm} up to a value of $v = 0.01 V$ is brought out by applying the above expression to values of v ranging from zero to $0.01 V$. On a unit basis the total increase in F_{\pm} over this wide range is only 0.005. If we take the value of F_{\pm} , which corresponds to $v = 0.01 V$, as a base, then the ratios of F_{\pm} to this base, for values of v increasing from $v = 0.01 V$ to $v = V$, are in conformity with the experimental results established by Kaufmann. In fact, the average conformity is greater than the average agreement arising

from the use of the following expression by Lorentz and Einstein:

$$\frac{m}{m_0} = \sqrt{\frac{1}{1 - \left(\frac{v}{V}\right)^2}}.$$

For Lorentz this expression indicates a contraction of the electrons during translatory motion due to the pressure of the ether. Referring to this theory of Lorentz, H. Poincaré states in his work "Science and Hypothesis": "It is in contradiction to Newton's law that action and reaction are equal and opposite—or, rather, this principle, according to Lorentz, cannot be applicable to matter alone; if it be true, it must take into account the action of the ether on matter, and the reaction of the matter on the ether."¹

The writer's expression, derived from the basic relations of the Space-Time Potential, affords a complete justification in the generalized conception of action and reaction involved in the principle of interaction between two material systems, the excitant and the concurrent systems; that is, between secondary and primary matter. Our expression conforms with the requirements of the Kaufmann effect, which shows that for a velocity increase beyond a certain crucial velocity the kern magnitude increases toward an infinite limit as the velocity of light V is approached. The inability of the electron to reach an infinite magnitude indicates that this kern can never acquire the velocity of light. The above facts involve the complete relativity of energy, force, mass, space, and time. See Appendix E.

109. The Structure of the Atom.

J. J. Thomson battled bravely and with profound mathematical sagacity to produce a stable mechanistic atom from an electronic protostructure. Thomson's atom consists of a positively charged (whatever that is) outer sphere having electrons disposed uniformly upon one or more inner concentric spheres. Rutherford, finding the Thomsonian atom incapable of explaining the numerous phenomena of radio-

¹ Science and Hypothesis, p. 175.

activity, adopted the Saturnian type of atom suggested by Nagaoka in 1904. Nagaoka's atom is practically the Thomsonian atom turned, as it were, inside out. A large positive nucleus is placed arbitrarily at the center, while the electrons are arranged upon a series of concentric exterior shells. Both types of atoms are expressions of a desire mechanistically to combine and unify the two phases, the positive and the negative, inherent in all phenomenal activity, without a sufficient ground in the nature of reality for the manner of their unification. In the very nature of things, these two phases have never been separated, therefore their unification is unnecessary. The Space-Time Potential shows us the nature of their eternal union, and we are not called upon to combine, in an arbitrary way, that which is already unified in a definite, unchanging manner. According to the Space-Time Potential, an atom is composed of neutral energons, capable of positive and negative interaction in conformity with the dictates of prevailing conditions, and arranged along concentric work loci whose common center constitutes the change point of the system. Every work locus has its positive and its negative phase. A positive work factor, with its inseparable yet equal negative antipodal, constitutes a unitary activity factor capable of two-directional activity (positive and negative) proceeding from a primary neutral condition. Matter is therefore capable of exhibiting three phases of activity—the neutral or primary phase and the positive and negative phases, known herein as secondary matter.

The molecule of the Space-Time Potential consists of atomic groups arranged along the work loci about a resultant change point in conformity with the requirements of the secondary function. In molecular systems we have seen that the radial magnitude, measured from the resultant change point to the atomic centers located upon work loci of equal potentials, are unequal.

110. Metageometry and Space.

The first hints of a metageometry or non-Euclidean geometry are found in the work of Nasir Eddin (1201-1274). Girolamo Saccheri (1667-1733), a learned Jesuit, studied the problem of parallels from a new viewpoint.

Another point of attack was secured by Johann Heinrich Lambert (1728-1777). The interest taken in this subject is evident when we mention the following renowned contributors to its theories: Gauss, Riemann, Lobatchevsky, Janos Bolyai, Helmholtz, Grassmann, Cayley, Felix Klein, Simon Newcomb, Paul Stäckel, Friedrich Engel, G. B. Halsted, H. Poincaré, B. J. Delbœuf, Ernst Mach, Bertrand A. W. Russell, Beltrami, and Sophus Lie.

Pangeometry or metageometry is essentially non-Euclidean. These speculations grew out of the consideration of that axiom of Euclid which states that but one straight line can be drawn through a given point parallel to a given straight line. According to Euclidean geometry, two straight lines are parallel when they lie in the same plane and cannot meet or approach each other, however far they may be produced. Moreover, since parallel lines cannot approach each other, they are everywhere equally distant from each other. Lobatchevsky and Bolyai claim that it is impossible to prove that only one straight line can be drawn through a given point parallel to a given straight line. Because of this alleged inability to prove this Euclidean axiom, Lobatchevsky assumed that several parallels may be drawn through a given point to any given straight line. Both Lobatchevsky and Bolyai believed that this assumption constituted a generalization which made of Euclidean geometry a particular and limited branch of an all-inclusive pangeometry. For Lobatchevsky the sum of the angles of a triangle is always less than 180° , and the difference between their sum and 180° is proportional to the area of the triangle. Furthermore, Lobatchevsky holds that a figure similar to a given figure but of different dimensions cannot be constructed. Pangeometry includes the following three distinct positions:

I. *Euclid.*

1. Only one straight line can be drawn through a given point parallel to a given straight line.
2. The sum of the three angles of any triangle is equal to 180° .
3. Space regarded as infinite. The perspective view of infinitely distant parts of a plane is a straight line.

II. Lobatchevsky.

1. From a given point outside of a given straight line two classes of lines may be drawn—*cutting* and *not cutting*. The not cutting lines constitute the parallel lines for Lobatchevsky, and of these there can be an infinite number.

2. The sum of the three angles of any triangle is less than 180° by an amount which is proportional to the area of the given triangle.

3. Space regarded as both immeasurable and limited. The perspective view of infinitely distant parts of a plane is a circle.

4. The straight line is the limit of curvature for a sphere of infinite radius and zero curvature.

5. Lobatchevsky's geometry deals with surfaces of constant *negative* curvature. These are the pseudo-spherical surfaces.

III. Riemann.

1. No line can be drawn through a given parallel to a given line in the space of Riemann.

2. The sum of the three angles of any triangle exceeds 180° by an amount which is proportional to the area of the given triangle.

3. The space of Riemann is unbounded but finite.

4. Riemann's geometry deals with surfaces of constant *positive* curvature. The infinitesimal dwellers in the spherical surface of Riemann may move forward forever, and yet their world is finite. Such beings by looking forward can see their own backs.

The extension of these and similar mathematical speculations has led to the notion of a space-family consisting of an endless variety of spaces. Tridimensional space is merely one type. The pangeometers insist that we must broaden our notion of space to include such types as space of four, five, and n dimensions. These flights of fancy should permit the existence of an appropriate order of beings corresponding to the various types of space. A four-dimensional being, according to this view, is as far superior to a three-dimensional creature as the three-dimensional being surpasses the two-dimensional animal. A two-dimensional being cannot remove itself from the surface which

constitutes its world of possible motion. The three-dimensional being can move along three distinct directions. Consequently, the three-dimensional being can easily remove the two-dimensional being from its surface world without crossing a single line within this surface. Similarly, the four-dimensional being can remove a three-dimensional being from the interior of a closed box without breaking through any of the enclosing walls. Whatever assurance we have that we shall not be suddenly removed from this sordid world of three dimensions without leaving the slightest trace must be grounded in an absolute faith that the four-dimensional beings are entirely free from thievish tendencies.

A cursory inspection of the speculations of the non-Euclideans shows startling quirks and curious quips in the mental processes of the modern mathematicians. There can be no real objection to Lobatchevsky's division of lines into two classes—the cutting and the non-cutting—provided that he refrains from making the word "parallel" synonymous with "not cutting." If we hold—as we must—that a straight line can be extended indefinitely without limit in its own direction, then only one "not cutting" line can be drawn through a given point outside of a given line. This one "not cutting" line will then constitute the parallel line of Euclidean geometry. If we arbitrarily limit the lengths of straight lines, then we can draw a number of "not cutting" lines, but how shall we determine the magnitude of the imposed limit? If we retain the definition of parallel lines which states that straight lines are parallel when they lie in the same plane and cannot meet nor approach each other, however far they may be produced, then it is folly to speak of an infinite number of parallel "not cutting" lines. Lobatchevsky entangles himself in a species of Kantian antimony in his speculations concerning the finite and the infinite. By placing unwarranted restrictions upon our *a priori* space construction he builds up a mathematical system of space relations which are mentally and logically consistent within the imposed unwarranted restrictions. This criticism holds, with equal force, for the system of Riemann and all the other pangeometers. All the meta-geometers fail to realize that space is both *a priori* and *a*

posteriori, that it has both subjective and objective significance. Were this not true, any person could construct for himself ideal spaces whose number would be limited only by the fertility of his imagination. We must draw a sharp distinction between *real space* and *mathematical space*. Speculations concerning mathematical spaces may be both amusing and profitable to the mathematician, but these mental products must be clearly differentiated and labeled as "speculative products" and not realities. Real objective space is tridimensional and all the speculative *a priori* spaces of the pangeometers are nothing more than mental by-products of objective space. It is impossible crudely to represent or interpret these *a priori* spaces without resorting to the relations which pertain to real space. It may be interesting to speculate concerning the antics of a two-dimensional being of zero thickness in a spherical surface, but common sense prohibits us from assigning genuine physical reality to such thought creations. We may be mentally pleased with the strict code of honor observed by the imaginary beings which inhabit an imaginary four-dimensional space, but to attribute reality to these creatures of imagination is folly. Every theorem of pangeometry can be restated in terms of Euclidean geometry. From ordinary Euclidean geometry we know that the sum of the angles of a spherical triangle is greater than two and less than six right angles. Riemann's geometry, therefore, is little more than a new version of spherical Euclidean geometry. It has been claimed for pangeometry that it is a broader concept than the Euclidean. There is little justice in this contention. Every form of pangeometry arises out of a limitation placed upon the concepts of Euclidean geometry. We cannot hope to broaden the "*a priority*" of our space notions by mental effort. The subjective spatial endowment of a normal human being stands in a constant relation to the objective world. Tridimensional space arises invariably as the result of interaction between the subjective and the objective world. No amount of mental effort will "broaden" this into a four-dimensional interactional resultant. Therefore we insist that every type of pangeometry is a particularization and limitation of tridimensional or Euclidean geometry. Moreover, our subjective endowment guaran-

tees the "a priority" of geometry and mathematics. It follows that the reality of speculative or mathematical spaces can be determined only through the experience of interaction with the objective world. Mathematical spaces which do not conform with this requirement of experience must be regarded merely as products of mathematical imagination. Real space guarantees the possibility of actual motion in every conceivable direction. Mathematical space is a mental product which involves laws of imaginary motion. When mathematical space is tridimensional, then the laws of imaginary motion agree with those of real motion. Bodies in space are limited and finite in magnitude. Things are related. Space is one type of relation existing between things. Relations admit of continuity, while things are discrete. Herein we find the norm of the significance of the infinite and the finite. Space being a relation, it permits of an infinite progression. Therefore we are correct in postulating infinity of space. Geometry is not an experimental science. There is no absolute straight line in nature. The nearest approach to a straight line in nature is the apparent boundary line between sky and sea, and we know that this boundary is not a straight line. Geometry is an *a priori* science arising out of our subjective endowment. No astronomical triangle will prove or disprove the *a priori* truth that the sum of the angles of any plane triangle is equal to two right angles. From the above brief discussion it is evident that the pangeometers have fallen into the same error that is so common with the modern physicist; that is, attributing reality to mere mathematical speculation. The facts of experience constitute the only true touchstone of reality. Using this criterion on the work of the pangeometers, we find it of speculative interest and value as a study in mathematical manipulation. As a contribution to our knowledge of space, the work of the non-Euclideans is of little, if any, value, for the reason that we cannot even think except in tridimensional terms.

111. Poincaré on Central Forces.

After this work was completed the writer ran across the splendid work of H. Poincaré entitled "Science and Hypothesis." In paragraph 108 we have already referred to this

work. The present chapter was written in order to make this work available to a larger circle of readers by eliminating the original mathematical analysis. Hence we had an opportunity to make particular mention of this work of Poincaré. It affords the writer exceptional pleasure to quote the following from the above-mentioned work of Poincaré:

"But have we any right to admit the hypothesis of central forces? Is this hypothesis rigorously accurate? Is it certain that it will never be falsified by experiment? Who will venture to make such an assertion? And if we must abandon this hypothesis, the building which has been so laboriously erected must fall to the ground. . . . But no system exists which is abstracted from all external action; every part of the universe is subject, more or less, to the action of the other parts."¹

These statements are in complete conformity with the contentions made in the preceding chapters by the writer.

¹ Science and Hypothesis, pp. 102, 103.

CHAPTER VIII

ELECTROLYTIC IONIZATION AND CELL ACTION

112. Ionization Hypothesis.

The electrolytic theory of dissociation maintains that molecular system passing into solution are separated into two kinds of ions having equal positive and negative charges. G. F. Fitzgerald says: "The supposed advantage of the free ion theory is not only illusory but misleading." H. E. Armstrong, J. W. Mellor, and others raise the following pertinent objections to the ionic hypothesis:

1. "In view of the great chemical activity of metallic sodium in contact with water, is it profitable to postulate the existence of the element sodium in contact with water without chemical action?"

Certainly a *charged* ion should show, even in solution, at least the same intensity of action as a neutral atom. Moreover, the free ion hypothesis does not give even a clue to the process by which a *neutral* atom becomes a charged ion in passing into solution.

2. "Bodies carrying electrical charges of opposite sign are attracted and cling to one another; if, therefore, a mobile solution contains *free* and *independent* ions carrying enormous electrical charges of opposite sign, how can the charged ions remain more than momentarily free?"

3. "If an ionized salt, say sodium chloride, is present in solution as a mixture of *Na* (+) and *Cl* (—) ions, it might be thought possible to separate the two components by diffusion or by other mechanical process."

4. "When a compound is formed from its elements, with the loss of energy, the compound cannot be resolved into its elements unless energy be supplied. It is therefore pertinent to inquire: What is the source of energy which leads to the fission of the molecule into ions carrying equal but opposite charges of electricity?"

5. "In the Hittorf experiments on the speed of migration of the different ions, the fact observed is the changing molecular concentration of the solution about the anode and cathode during electrolysis: the *extraordinary hypothesis* is that during the passage of the current the *anions and cations move in the same electrolyte with different velocities, and yet the anions and cations are given off at the respective electrodes at the same time.*"

6. In spite of the ionic hypothesis, chemical reactions do take place in non-conducting solutions, and these reactions are similar in result and speed to those which occur in conducting aqueous solutions."

Dr. J. W. Mellor comments upon these facts as follows: "The ionic hypothesis cannot, therefore, ignore these observations if it is to win a permanent place among the conquests of science."

The author presents the following hypothesis, based upon previous conclusions, as a means of overcoming the real and serious difficulties involved in the ionic hypothesis:

1. All interaction involves the concomitance of *ascending* and *descending processes*. The work increments involved in the former processes are equal to the work decrements involved in the latter. For each ascending process there will be one descending process.

2. The products of solution appear as *neutral ionic pairs*. The *neutral couples* result from the interaction of solvent and solute. This assumption is a direct corollary of the first assumption. Odd solution components are impossible under the hypothesis of a dual process involving a simultaneous and equal augmentation and degradation.

3. The ions are capable of a *three-phase change* involving *two work steps*, equal in magnitude but opposite in their direction. The phase change in the *neutral energon* is concomitant and in the same direction with the phase change in the ion.

4. The phase association is such that the *electron* appears at the *high phase*, the *energon* at the *neutral phase*, and the *positon* at the *low phase*.

5. The algebraic sum of the work done in any system is zero. We shall consider two cases by way of illustrating the application of our hypothesis.

113. CASE I. ZINC IN THE PRESENCE OF HYDROCHLORIC ACID

Zinc goes into solution, replacing hydrogen and forming zinc chloride. Hydrogen gas is liberated. Hydrochloric acid is in the *neutral phase*, hydrogen and chlorine existing as *neutral ions*. The difference of potential between metallic zinc (low phase) and chlorine (neutral phase) is greater than the difference in potential between metallic zinc (low phase) and hydrogen (neutral phase), therefore metallic zinc (low phase) goes into solution on an ascending gradient, becoming ionic zinc (neutral phase), replacing the ionic hydrogen (neutral phase), which becomes hydrogen gas (low phase) along a descending gradient. The algebraic sum of the work done in the system is zero because the appearance of one positive work unit is concomitant with the production of an equal negative work unit.

114. CASE II. THE DANIELL CELL

Metallic zinc in the presence of a solution of zinc sulphate. Metallic copper in the presence of a solution of copper sulphate. Mechanical mixing of the solutions prevented by a porous partition. The interaction of water and zinc sulphate produces the *neutral couples*, hydroxidion (hydrogen and oxygen), hydrion (neutral hydrogen); and zincion (neutral zinc), sulphaniion (one atom of sulphur, four atoms of oxygen). Similarly the interaction of water and copper sulphate produces the *neutral couples*, hydroxidion (one neutral hydrogen and one neutral oxygen atom), hydrion (neutral hydrogen); and dicuprion (neutral copper ion), sulphaniion. We shall use the subscripts *h*, *n*, and *l* to signify *high*, *neutral*, and *low* phase, thus:

Sulphaniion (SO_4) in the low phase = $(\text{SO}_4)_l$,
 Zinc (Zn) in the neutral phase = $(\text{Zn})_n$, etc.

We must now seek the direction of the *stress relief gradients* in the systems on both sides of the porous partition. On the zinc side the difference in potential between metallic zinc (Zn)_l (zinc, low phase) and sulphaniion in the neutral phase (SO_4)_n is greater than the difference in potential between zinc neutral phase (Zn)_n and (SO_4)_n.

Since each work step involves a constant increment or decrement in the potential difference, it follows that the potential difference between any two ions remains constant throughout the phase change. Now since the crucial ionic pair in the system is the $(Zn-SO_4)$ group because this involves the greatest potential difference,—(the possible combinations are $(Zn-H)$, $(Zn-OH)$, $(Zn-SO_4)$, $(H-HO)$, $(H-SO_4)$, $(OH-SO_4)$, and (Zn_n-Zn_l)),—it follows that the group (Zn_n-SO_4) is the determinant of the system because its potential difference is greater than (Zn_n-SO_4) . The difference of potential between $(Zn)_n$ and $(Zn)_l$ is an ultimate unit of potential difference hence this group cannot be considered.

In the copper sulphate chamber similar group combinations can be made by replacing zinc with copper in the above groups. *The combined systems will strive for the production of a minimum resultant difference of potential.* Consequently the crucial group in the copper-sulphate chamber is the group which involves the lowest difference in potential because this group will establish the maximum resultant potential difference. Now since the difference in potential between $(Cu)_n$ and $(Cu)_l$ is one ultimate unit, this is the crucial group. The active groups, therefore, are the $(Zn-SO_4)$, (Zn_n-Zn_l) , $(Cu-SO_4)$, and (Cu_n-Cu_l) , and they become the determinants of the resultant potential difference or E. M. F. of the complete system. Since the groups (Cu_n-Cu_l) and (Zn_n-Zn_l) both involve one ultimate unit of potential difference along oppositely directed gradients, the former being descending and the latter ascending, these differences neutralize each other. Hence the resultant E. M. F. of the cell is determined by the $(Cu-SO_4)$ and $(Zn-SO_4)$ groups.

Since (SO_4) is common to both groups, the determination of the E. M. F. of the system reduces to the determination of the potential difference between (Zn) and Cu). The well-known procedure is as follows:

$$\begin{aligned}
 & (Zn - SO_4) - (Cu - SO_4) \\
 & = \{0.50 - (-2.2)\} - \{-0.60 - (2.2)\} = +2.70 - 1.60 = +1.10 \text{ volt;} \\
 \text{or, } Zn - Cu \\
 & = \{0.50 - (-0.60)\} = +1.10 \text{ volts.}
 \end{aligned}$$

That the osmotic pressure and solution tension are ultimately due to the same causes ought to be evident.

We show diagrammatically, in Fig. 15, the cyclic changes which take place in the members of the active groups. Ascending processes are represented by arrows pointing upward, and descending processes by arrows pointing downward. The three phases are represented by the subscripts *h*, *n*, and *l* attached to the chemical symbols, and the letter *U* means one ultimate work unit which is equal to the product of the electrical charge and the ultimate unit of potential difference. The notion that an electrical charge is an independent entity capable of being attached to and detached from matter involves insurmountable difficulties. The charge is a physico-mathematical concept crystallized out of the content of an activity which includes it and all other similar crystallizations. The material form of the energy or work unit *U* is a three-phase system capable of passing through two work steps. At the *high phase* it is the *electron*, at *neutral* it is the *energon*, and at *low* it is the *positon*. For work to be done a change in phase must take place. At the incipiency of the action the members of the active groups are neutral and the zinc and copper electrodes are at the low phase. Both members of every ionic couple are affected during the action. An ascending process in one member involves a descending process in the other. The positive work is always equal to the negative work in the ionic couple.

The changes which take place in the cell may be analyzed into the following steps (shown diagrammatically in Fig. 15), without reference to an actual time sequence:

1. $(\text{Cu})_n$ descends to $(\text{Cu})_{n'}$, $(\text{SO}_4)_n$ ascends to $(\text{SO}_4)_{n'}$;
2. (Cu) is bivalent and it gives up two work units $2U$ to the copper electrode.
3. In the external circuit $2U$, (positons) can ascend to $2U_n$ (energons) doing two ultimate units of work along an ascending gradient.

In the copper sulphate chamber metallic copper $(\text{Cu})_{n'}$ is deposited on the copper electrode. We leave $(\text{SO}_4)_{n'}$ at *high phase* temporarily while we pass to the consideration of the activities in the zinc-sulphate chamber.

4. $(SO_4)_n$ descends to $(SO_4)_m$, $(Zn)_n$ ascends to $(Zn)_m$;

5. $(SO_4)_l$ is bivalent and it gives up two work units $2U_l$ to $(Zn)_l$ (metallic zinc) of the zinc electrode.

6. $(Zn)_l$ ascends to $(Zn)_n$ due to the addition of the two work units $2(U_l$ to $U_n)$. Migration takes place and $(Zn)_n$ replaces $(Cu)_n$.

7. $(Zn)_n$ descends to $(Zn)_m$ concomitantly with process number 6.

8. $(SO_4)_l$ ascends to $(SO_4)_m$ concomitantly with $(SO_4)_n$ descending to $(SO_4)_m$.

All the members of the active groups in the electrolytes have gone through a cyclic change from the initial neutral phase and back to neutral. For every descending process there has been an ascending process. Two free positons ($2U_l$) have been given to the copper electrode. In the external circuit these two units, in passing from low to neutral phase, can do two ultimate units of work along an ascending gradient. Corresponding to this ascending process in the external circuit, a descending process from high to neutral will set in.

Electrolytes of different concentrations in the presence of electrodes of the same material constitute another form of an unbalanced system. In such an unbalanced system ascending and descending processes will be established and their continuance is assured until the concentrations become the same.

We have previously stated that the concurrent system may also be considered as contained within the material group. This involves the existence of neutral energons within the cell system. Our reactions may be explained from this standpoint. The introduction of a positon into the concurrent system disturbs the neutrality of one energon because it is in the nature of an influx of energy into the concurrent system. The energon members of the concurrent system must suffer radial expansion when positons are introduced in order that the resultant potential difference may remain unchanged. One neutral energon is augmented into an electron (high phase) for each excitant positon introduced into the concurrent system.

If U is the ultimate unit of work, then, irrespective of direction of the gradient, we have

$$U = (U_t \text{ to } U_n) = (U_h \text{ to } U_n) = (U_n \text{ to } U_t) = (U_n \text{ to } U_h).$$

The positon is an ascending process and may be regarded as positive (+), and it is equal to $+U$ in magnitude. The electron is a descending process and may be considered as negative (-), and it is equal to $-U$ in magnitude.

The addition of a positon ($+U$) to one member involves the addition of an electron ($-U$) to another member. If a member is at high phase, then we may regard this as being due to the application of a positon to it when at neutral. Similarly, from low to neutral involves one positon. The application of an electron to a member at high will bring it to neutral accompanied by the liberation of an energon which rejoins the concurrent system. The application of an electron to a member at neutral reduces it to low, with the liberation of a positon. After all, this is merely another way of considering ascending and descending processes, the results being identical.

The cell actions may be set forth in terms of the following reactions:

In the Copper-Sulphate Chamber

1. $\begin{cases} (\text{Cu})_n - 2U = (\text{Cu})_t + 2 \text{ Free Positons.} \\ (\text{SO}_4)_n + 2U = (\text{SO}_4)_h. \end{cases}$ Copper deposited.

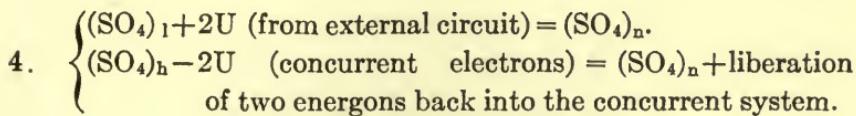
The two free positons pass by way of the copper electrode to the external circuit.

In the Zinc-Sulphate Chamber

2. $\begin{cases} (\text{SO}_4)_n - 2U = (\text{SO}_4)_t + 2 \text{ free positons which are given} \\ \quad \text{up to metallic } (\text{Zn})_t \text{ of the electrode.} \\ (\text{Zn})_n + 2U = (\text{Zn})_h. \end{cases}$
3. $\begin{cases} (\text{Zn})_t \text{ (metallic)} + 2U = (\text{Zn})_n \text{ (ionic) metallic zinc goes} \\ \quad \text{into solution.} \\ (\text{Zn})_h - 2U = (\text{Zn})_n. \end{cases}$

This leaves $(\text{SO}_4)_h$ in the copper-sulphate solution and $(\text{SO}_4)_t$, in the zinc-sulphate solution.

The external circuit must liberate two positons (+2U) for the two received, and these, when they enter the cell, augment two energons in the concurrent system into electrons (-2U), hence the cycle is completed by the following reactions :

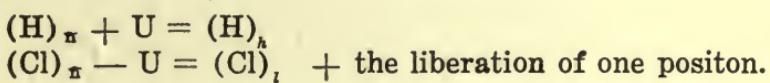


Summation of U Values

It is seen that the algebraic sum of the *U* values in the above four steps is equal to zero.

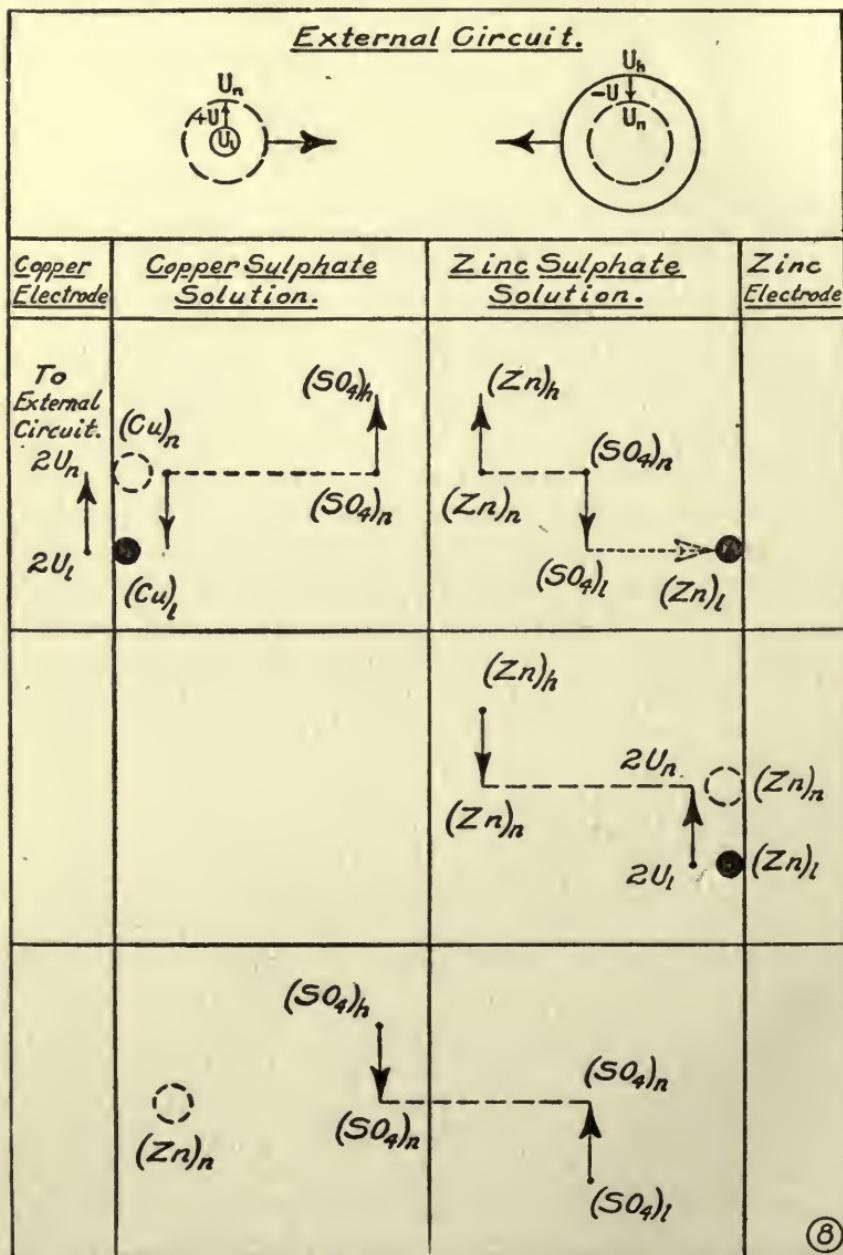
115. Work of Decomposition.

Suppose a battery of these cells is used to send a current into a solution of hydrochloric acid (*HCl*) in order to decompose it. The two members *H* and *Cl* of the ionic couple are neutral, being in solution. For every positon (+U) introduced into this system an electron (-U) is formed in the concurrent system. When a positon is added to one member of the couple a concurrent electron is added to the other. Now since (*H*) and (*Cl*) are both univalent, we may write the reactions as follows:



This leaves (*H*) and (*Cl*) at high and low phases respectively, with one work step *U* intervening to neutral for each. The electric current consists, then, in a flow of positons in one direction, and the generation of electrons from energons in the concurrent system and their flow in the opposite direction—positon through electrons. Mechanical energy expended in the current generator produces electrons from energons with the concurrent compensating production of positons. The cell process liberated positons, with the concurrent production of electrons in the concurrent system. Activity manifest as primary matter or energons becomes secondary matter manifest as positons and electrons; and matter is merely a phase of activity.

Fig. 15.



(8)

CHAPTER IX

THE FOUR WORLDS

116. Résumé

In this work we have dealt with interaction in the physical universe. We have found that things are interdependent and not independent. In their totality they constitute a unitary cosmos. The ultimates of things are action centers. These action centers manifest in space and time in accordance with the deterministic dictates of their God-given characteristics or endowments. The uniformities of physical action may be described in terms of natural laws. Nodal deviations from finite and partial uniformity are teleological resultants which are in complete conformity with the principle of non-contradiction. Space and time are forms of apprehension possessing both objective and subjective significance. Because space and time are not things, it does not follow that they are unreal. If a certain type of action occurs when the distance between two things is small, and when the distance is increased this action fails to occur, it does not follow that space or distance is an action-prohibiting entity. All that follows from this fact is that, because of the change in distance, new arrangements of the activity factors have been established by the change in the relative location of the things. A change in location involves a variation of the quantum of the intervening concurrent system together with a change in the total action setting. If a certain type of action fails to appear, we attribute the failure to this new action setting and not to any prohibitive action of an independent spatial entity. We have seen that physical action ultimately depends upon the sustaining influence of the Being of God. We look upon the universe as due to a free creative act of God. We think of God as both Immanent in the cosmos and Transcendent above its finite limitations. We find both purpose and teleology in the uni-

verse, and we regard both as phases of the principle of non-contradiction.

The scope of this work, being limited to the physical universe, prohibits a discussion of its relation to the worlds of consciousness and subconsciousness. However, we shall briefly outline the direction which the logical development of our position must take when the worlds of consciousness and subconsciousness are included within the created cosmos.

117. The World of Subconsciousness.

The stream of consciousness flows, as it were, between two banks: one the world of activity, matter, and life; the other the world of subconsciousness. The subconscious world is a vast region comparatively unexplored and little understood. The bulk of conscious and unconscious experience is, as it were, filed away in the eternal vaults of this wonderful world. Under certain abnormal conditions the vaults are opened and the stored information is again revealed to conscious minds. The subconscious world is the background of our conscious activity, and few are those who have not, in some moment of their life, been in rapport with the groundwork of conscious life. The extent of this rapport is only a question of degree; in some individuals it is more marked than in others. In passing from the subconscious to the conscious, reality is differentiated into temporal series and spatial appearance through the forms of conscious apprehension. Looking through the binoculars of space and time, the finite self sees reality as the moving film of life, the present receding into the past and the future moving into the present. The binoculars of space, time, and causality would fail us in our differentiation of the world of reality unless the distinctions possessed objective significance. The finite selves are free factors in the making of the film of reality. At the same time we are being molded and formed through interaction with the other constituents of reality. Our pilgrimage from the most remote of the world projections leads us back to God our Creator. The principle of non-contradiction, arising from the Being of God, like the fountain stream projected high into the atmosphere and into the utmost regions of existence, unifies the

contradictions of all finite existence, harmonizing finite being with the Reality of the Infinite Creator.

118. The Inorganic World.

The inorganic world is the world of physical determinism and natural law. By natural law we do not mean some external governing entity alien to things, but we mean that consistent rational record of the action of things which to us appears as laws and for things is a partial account of the manner of their interaction. In the inorganic world the interaction relations between the physical centers is equivalent to a well-defined sensitiveness of each center to the rest which constitute its environment. The magnitude of this sensitiveness grows as the action groups become more complex. The sphere of interaction increases with this growth in sensitiveness. From monon to mind, the growth is continuous. This constitutes the essence of evolution. By this statement we do not mean that all forms of existence are developments from one existence type. The great complexity of the universe points to a great diversity of beginnings. The attempted unifications and simplifications of the various evolutionary schools are, for the most part, total failures because they do not begin to do justice to the complexity of the cosmos. In the inorganic world there is no genuine freedom in the sense of the possibility of a new creation which augments the world content and the free individual.

All change is an exchange or interchange according to natural law in this purely physical world. The only freedom we find in the inorganic world is the freedom of exhibiting that given and fixed character of the action center which lies at the foundation of natural law. This constant display of fixed character is called "determinism." Freedom and determinism are not incompatible. In the conscious world freedom would result in chaos unless exercised within the boundaries of physical determinism. Thought activities would be ineffective unless focused upon an environment which may be defined in terms of principles and laws. Thought as free will could find no point from which to initiate action, with even the remotest assurance of a definite result, unless the physical world, the environment,

could be relied upon to react in a definite, determinable manner.

119. The Organic World and the Entity of Life.

In the inorganic world all is mechanism as far as phenomenal appearance is concerned. As the created work of God, the inorganic world is more than mechanism, for God expresses His Eternal Reality in the inorganic world by His Immanence in conjunction with His Eternal Transcendence. Consequently the inorganic world is more than a mere machine. For this reason science cannot explain the physical universe in terms of mechanism alone. In one sense of the word, the monon is an individual if separateness or discreteness is all that is meant by individuality. Mere discreteness, however, is not a criterion of genuine individuality, for it conveys the implication of being a part of a larger totality which itself may constitute a real individual if the system is an interacting unity, as we have been forced to assume. A contentless number is a mere mathematical abstraction. Consequently the number one is not a real unity because it is a conceptual abstraction devoid of content. Unity, then, is continuity of activity, a persistence of exhibition of definite characteristics throughout a multiplicity of change. This idea of unity does not involve the necessity of discrete physical parts, for continuity throughout change is the essence of unity. This is the type of unity exhibited by the soul. It does not follow that because the soul is not composed of discrete parts it is a mere mathematical abstraction. The soul is a higher form of unity whose activity content is manifold. The life entity is a unity of the same order as the soul entity. The distinction between these two types of unitary entities is to be found more in degree than in type or kind. The fact that the life and soul entities are unities of a higher order than the merely physical unities does not preclude the conjunction of these unities into resultant unities of another order, for we have already shown that unity devoid of multiplicity is a mere mathematical abstraction. We hold that the phenomena of life and consciousness have not been and cannot be explained by any system of philosophy, no matter

how subtle in its excruciating verbosity, which tries to merge the three essences of cosmic reality—that is, the physical essence, the life essence, and the soul essence—into one primordial parent entity type which is capable of developing or evolving into the higher types through interaction in an environment composed of nothing but these same primordial existence types. This is exactly what modern philosophical evolution tries to do. The attempt is an ignominious failure. Differences cannot arise out of sameness. If we place one hundred marbles in a box and shake them with utmost vigor, we get nothing other than one hundred marbles for our effort. Our effort does not produce one apple even if we add another hundred marbles to the original number. This popular modern intellectual mania seems to break out continuously in an attempt to evolve the complex all out of the simple one. This intellectual mania is such a common malady that he who refrains from joining these modern scientific dervishes is charged with being simple-minded and demented. We maintain that religious intuition is nearer to the truths of ultimate reality than all the subtle speculations of these modern sophists. We contend that the organic center is a resultant unity arising through conjunction and interaction between the life center and suitable aggregates of inorganic centers. We extend the principle of interaction to the organic world. In the monons we find basic fundamental characteristics common to all. Nevertheless, we recognize differences in the characteristics of the monons. The physical universe cannot be generated out of mere number. Similarly we recognize differences in the life ultimates. We shall give the name *vitons* to these life ultimates. Like the monons, the vitons are capable of exhibiting positive and negative action phases in conformity with the principle of non-contradiction. Throughout all the worlds of being, this differentiation of unity into a positive and a negative phase is found. In the conscious world we find the unity differentiated into pleasure and pain, good and evil, truth and error. In the organic world the center is responsive to the modeling influence of environment and it exhibits the rudiments of individuality.

120. The Conscious World and the Entity of Soul.

The problem of operation, control, and interaction is more difficult when we ascend the thermometer of organized life and reach the more complex groups. In the more complex groups we find the nervous systems whose functionings provide for the handling of the mechanical problems involved in the operation and control of the bodily movements, thus making possible the representation and realization of such desires and interests as tend toward the further development of a harmonic individuality. In the highest organic complexity, the human body, we find consciousness fully developed. The conscious being is a resultant unity arising through the conjunction and interaction between the soul and suitable aggregates of organic centers. Thus the principle of interaction is extended to the world of consciousness. Creation did not cease when God created the physical universe. Free creation is distinctive of conscious life; in fact, it is one of its highest forms of expression. Our concept of God must therefore include creation as an abiding form of expression of the infinite Being. God's Immanence and Transcendence assure the continuous responsive expression of His Free Creation in the cosmos. The creation of souls is an expression of the Infinite and Non-Temporal Being of God manifest and immanent in the finite world of space, time, and secondary causation. The resultant unitary being which is produced by the conjunction and interaction of the soul with the organic system develops into complete consciousness contemporaneously with the observable development of the organic, nervous, and brain structure. In the conscious world individuality begins to assert itself in a pronounced and distinct manner by attempting to reconstruct its environment. This attempt is a primary manifestation of the will. Moreover, there is noticeable an attempt to interpret environment, and this constitutes the beginning of knowledge or cognition. This is what we call mentality, and thus arises the unitary world of mind, which may be differentiated into thought as will and thought as cognition. Introspection separates mental activity into the two principal components, will and cognition. In reality they are never found divorced. Sometimes will appears to

be on the crest of mind life, at other times it is cognition, but this appearance of dualism is due to the ineffectual attempts of mind to catch all of itself in one single moment of time. Mechanism becomes the servant of consciousness with the development of the unitary being. Consciousness demands the performance of certain movements with the minimum of effort. The nervous system, begining as mere reaction to the simplest stimuli, develops into a complex mechanism in accordance with the requirements of soul life. Soul life and physical mechanism blend into one unitary life, and perfect interaction exists in all the stages of development. Conscious soul life is the non-spatial phase of the life of mind; the neural processes are the spatial manifestations of that activity. The brain and the nervous system are like the cutting edges of the two blades of a pair of shears. Whenever the psychical movement is effective within the world of space and time there the cutting edges are in action. The interacting, moving content of the soul life propels the action in a direction which is the resultant of this soul content. Genuine freedom means that activity is given its course from the organized soul content. Thought as will produces new thought solutions tending toward action. Thought as cognition produces new thought creations. Both thought as will and thought as cognition are phases of the unitary life of the soul.

121. Relation Between the Conscious and the Subconscious Worlds.

The interaction between the soul and its organic mechanism may vary in intensity. When the interaction is sharply defined and of the maximum intensity, then conscious awareness is at its highest level. There is also a lowest level corresponding to that minimum intensity of interaction which is capable of producing conscious awareness. These limits themselves may vary because of other interaction conditions. However, conscious life may be said to be bounded by a high and a low level of interaction. Below the low level we have the subconscious life of the soul. There the results of intense interaction—that is, conscious life—are stored for all eternity. There the precipitates of all conscious activity are preserved as the everlasting rec-

ords of temporal life. We may say, then, that soul life has a transcendent and an immanent phase. The immanent phase corresponds to the conscious life, while the transcendent phase corresponds to the subconscious life. In this respect the life of the soul is somewhat similar to the Life of God. One important difference lies in the fact that the soul did not create its organic mechanism. There is one striking similarity, that is, the Life of God does not depend upon the continued existence of the cosmos which He created, and the life of the soul continues after dissociation with the organic mechanism. We know very little concerning subconscious interaction. Many indications point to the fact that the soul is capable of subconscious interaction, but we know little of the *modus operandi*. The subconscious content may be, as it were, the glass through which the soul sees God dimly. The religious intuition of the primitive is not mere superstition. It is grounded in a deeper reality than superstition. The universality of the religious intuition points to a common background of conscious soul life; that is, the subconscious soul content. Thus man is truly made in the Image of God.

122. The Categories of Reality.

Reality may be distinguished as *Absolute* and *Relative*. These two manifestations are not isolated and estranged existence types constituting alien dualistic principles having no binding ties or interrelations. True unity is brought about only through interrelations. In this sense, therefore, the Absolute Reality and the Relative Reality constitute a unity despite the fact that they are not identical. A unity which merges the Absolute into the Relative or the Relative into the Absolute cannot be constructed philosophically except by resorting to the idea of interrelations between multiplicity, which then merges multiplicity into unity. If it is thought that the word "unity" lends profundity to philosophic contemplation, then we have as much right to claim unity for our two types of reality as those philosophers who attempt to remove any distinction between these two types. There must be differences in the content of multiplicity if a real unity can be established. A unity without distinctions and variations in its content is a mere

mathematical abstraction. Hence we maintain that our position is no more dualistic than that of the most subtle monist whose principal endeavor it is to merge multiplicity into unity. The monist denies that his endeavor results in an identity, nevertheless he charges us with gross lack of philosophic insight and acumen whenever we apply his own procedure to a content, grounded in fact, which will, when developed to its logical conclusion, exhibit a genuine religious value. We speak of reality as relative in order to emphasize the fact that it owes its significance to the Absolute Reality—God. Moreover, Relative Reality is relative by virtue of genuine and real relations to God. We may formulate the categories of reality as follows:

ABSOLUTE REALITY

GOD

A Timeless Transcendent Reality, Immanent in Temporal Finiteness

The Absolute is non-spatial, non-temporal, and capable of Absolute Free Origination. God is therefore the Primary Causation in distinction to Secondary Causation, which manifests in finiteness in conjunction with the forms of space and time. God is Absolute Truth, Absolute Freedom, and Perfection; therefore His Omniscience and Omnipotence follow as logical consequents. God is the Absolute Creative Being.

RELATIVE REALITY

I. The Inorganic World

The inorganic world is subdivided into:

1. The *Primary World*, composed of:

- a. Monons, the primordial form of activity centers.
- b. Energons, the gyratory groups composed of monons.

These gyratory energons constitute our *concurrent system* of *primary matter* which interacts with *secondary matter* in the production of physical phenomena. The energons are the *neutral phase* of matter.

2. The *Secondary World*, composed of

- a. Electrons, the *negative phases* of the energons.
- b. Positons, the *positive phases* of the energons.

These groups constitute the *excitant system* of *secondary matter* which generates physical phenomena through interaction with the *concurrent system or primary neutral matter*. Complex material aggregates are built up from these secondary elementals.

Principal Characteristic of the Inorganic Centers

1. Capable of self-maintenance.
2. Capable of definite physical combinations.
3. Limited or deterministic sensitiveness to environment.
4. No genuine creative freedom.
5. Differing in many characteristics.

II. The Organic World

We subdivide the organic world into:

1. *Primary Activity* composed of *Vitons* manifesting the Principle of life. The Vitons are the Life Ultimates. We may say that the Vitons are elementary Souls lacking that potentiality which insures development into the highest form of conscious life. The Vitons differ in many of their fundamental characteristics. All Vitons manifest the Principle of Life given to them by a creative act of God, who is the Source of Life. God's ever present Immanence insures to every organism an elementary soul or viton which is in harmony with its being.

2. A *Secondary Activity* composed of groups of varying complexity built up of *secondary matter*. The organic molecular groups are generally very complex.

The resultant unitary organic center is due to the conjunction and interaction of the Primary Activity of the Viton and the Secondary Activity of Secondary Matter. Because of its content of secondary matter, the organic center can interact with primary matter.

Principal Characteristics of the Organic Center

1. Capable of self-maintenance.
2. Capable of definite physical combinations.
3. A greater sensitiveness to environment.

4. Capable of exhibiting an indeterminate creative impulse; that is, limited freedom.
5. Differing in many characteristics.

III. The Conscious World

The conscious world may be subdivided into:

1. A *Primary Activity* composed of Souls manifesting the Principle of Free Individuality. Herein lies the distinction between the Soul and the Viton. The soul is of God through His act of creation.
2. A *Secondary Activity* composed of highly developed organic systems capable of minute shades of responsive interaction.

The resultant unitary conscious center arises through conjunction and interaction of the soul with its organic system. Development is not precluded by this interaction, but, on the contrary, it is fostered by it. The modeling influence of environment is included as a fact due to general interaction.

Principal Characteristics of the Conscious Center

1. Capable of self-maintenance.
2. Capable of definite physical combinations.
3. A highly attuned sensitiveness to environment.
4. Capable of reconstructing its environment. This tendency constitutes the basic root of the will.
5. Capable of producing new thought solutions tending toward action. This is thought as will.

Results in the production of the moral structure.

6. Capable of interpreting its environment. This tendency constitutes the basic root of cognition.

7. Capable of producing new thought creations. This is thought as cognition. Results in the production of art, literature, science, and philosophy.

8. Capable of expressing a more complete individuality through the exercise of a freedom which is only partially limited by the necessary conditions of action imposed by environment.

IV. The Subconscious World

We may differentiate soul life into:

1. A *Primary Activity* consisting in the soul life below the lowest level of consciousness.

2. A *Secondary Activity* consisting in the conscious life brought about by interactions between the soul and the organic system above the lowest level of consciousness.

The subconscious world pertains to the *primary activity* of soul life. Although the content of this primary or subconscious activity is for the greater part conjectural, nevertheless we have a quantum of evidence which at least indistinctly indicates some phases of this hidden content. It is highly probable that this subconscious phase of soul activity is capable of and includes within its content:

1. The indestructible record of perceptions, conscious thoughts, and acts.

2. Producing the so-called abnormal psychical phenomena.

3. Interaction with other primary subconscious activities.

4. Projecting portions of its content above the lowest level of consciousness under suitable conditions of interaction.

5. Receiving certain types of direct or intuitive knowledge and revelation.

6. The groundwork of instinctive responsiveness.

7. The groundwork of the intuitions of religion and faith in an ethical order.

123. Chance and Predetermination.

Is life a mere rattling of the chains of finite servitude? Are the links in the chain of life forged before our advent into the arena of finite existence? If we reject this view, are all events merely the chaotic outcome of chance and contingency? We take the position that both these views are erroneous because they are the extremes of a view which includes a modified interpretation of both. In creative art we find the essence of a genuine freedom. Conscious life cannot be predicted with any greater certainty than art, which owes its novelty to the mental content and depth of penetration of the artist's mind. Art owes its existence to the initiative and creative constructiveness of the artist. This is all that can be asked for freedom. If environment is the only factor in the making of an individual, then two minds in the same environment should be as like as two

peas in a pod. We do know, however, that in the same home two children carve out different mental worlds for themselves from the same environment. Without freedom's creative impulse, the conscious world would show but little diversity. True, you will grant, but individual differences are themselves factors that are predetermined and as such have previously existed somewhere. In other words, no really new element is to be found in the entire realm of conscious life. This is a fatalism which chains the soul to eternal serfdom. A past which is a genuine past, and as such does not exist, can have no determinate influence upon the present in producing the future. Given the artist and his mental content, no one can predict the nature of the work of art. The result is a genuine novelty, unaccountable and unpredictable. If all the mental content is known to a greater mind, then only is prediction possible. We can mean nothing less by prediction than that certain results have been brought about before they can be observed as phenomenal facts. Even in the realm of logic the creative principle of freedom reforms a world content into startling and novel combinations. The physical world in which we live is a world of determinism, understandable in terms of natural laws. The mechanistic elements of our body belong to the world of determinism.

This constitutes the physical logic of the universe. Without this background, rational action is impossible. A knowledge of this world of predictable and definite consequences is part of the content of mind gained through interaction with environment. All we can ask is our share in the creative activity of a world which includes physical determinism. This is the only form in which predetermination enters as an influencing element in our creative activity. In fact, creative activity requires this known and definite foundation for its expression and realization. Our soul content is the fountain from which action arises. Although action is dependent upon mind content, nevertheless the soul is able to originate and create new thought and action departures. The chance element is in the nature of an opportunity to originate and initiate. Chance as a chaotic contingency is not found in the world of consciousness. All action proceeds from the content of the self. The new does

not arise from chaos, but from the cosmos of the self. Love and logic find no room in fatalism, that dark hand from a remorseless beyond, which drags the self hither and thither with predetermined precision, calculated by the infernal master mind of a being inimical to all forms of genuine self-expression. Fatalism annihilates individuality. The two cannot exist together. A thing whose movements are prearranged and controlled is not an individual, but a machine. At the time of the act it (the act) is characteristic of the self which then exists. The act is a deputy of the soul content which brings it into being. Freedom does not mean that you, being what you are at this moment, can act in a manner which differs from the resultant of your momentary mind content. You are what your action responses (reactions) to an active environment have made you. You may become a radically different self due to your last act. Your self is not a static thing; it is a dynamic action center changing during interaction. As your self develops into a fuller individuality, a greater world of spiritual content, your resultant acts partake of a larger and more significant freedom. It may now be maintained that our arguments have led us back to determinism, for have we not admitted that the agent's act is a mere result of his soul content at the given time? The agent could not have acted in a different manner, and consequently the inference is that the agent is absolutely determined. We grant this without hesitation because this is what we mean by a rational freedom, but *we do not grant that the act was determined for the agent, but by the free choice of his own individuality or self.* Genuine freedom is a measure of the magnitude of the individuality; it does not measure the magnitude of some other alien self. Our freedom is in the nature of a creative determinateness and not an external absoluteness or manifestation of chaotic chance. The creative work of art finds its expression in and through a mechanical system. The physical world and nature constitute the instrument of expression of spiritual values. Mind is not a compound formed by association of a number of unrelated and separate content units. It is rather a growth by differentiation from a unity which pervades the conscious being and the physical universe. We hold, therefore, that the unitary being of the soul is free in its activity

expressions, that its activity expressions are genuine self-expressions and not expressions of some external agent, and that the manner of the activity expressions is influenced and partially controlled by the necessities imposed by environment.

124. The Assurance of Immortality.

The finite self longs for the transformation of the discords of life into harmonious forms. This is the mainspring of life and the root of hope. The path of discord leads the finite self out of itself and beyond itself in the contemplation of a condition of existence in which its loftiest desires may find their completion. In the final analysis we desire that the best in us shall persist. The best in us includes what is beyond us. The finite self seeks its fuller expression in a perfection which cannot be realized during finite life. Souls are hurled, as it were, from the Heart of the Infinite into the temporal world of discord and experience, where they are moulded into self-conscious beings of thinking wills seeking perfection because aware of imperfection, and living in hope of an ultimate return to a timeless world of perfection and harmony. *The universality of this hope is the greatest natural law in the universe.* It is the source of that feeling of certainty that our finite self will not be denied the realization of its desire for a fuller expression in a life beyond this. If this feeling is mere superstition, then the world becomes meaningless. The universal belief in immortality cannot be a mere development from experience and environment. Even the most primitive of the ancient races of mankind held the belief in immortality in some form. This belief could not have arisen in the primitive mind from experience and environment. Physical evidence showed primitive man nothing but an absolute end with the death of the body. Therefore we maintain that the belief in immortality is more than belief: it is a universal factor in the subconscious content of the conscious self. No matter how subtle the attempt may be to derive the belief from experience, the universal evidence of bodily death constitutes a universally true fact out of which a normal mind can derive nothing but an absolute negation of immortality. Despite this observation, the fact of bodily death has emphasized the belief in immortality. Therefore the normal

mind is either universally inconsistent and incapable of deriving correct inferences from facts, or the belief in immortality is grounded in the depths of reality and is known as an eternal verity to the subconscious phase of soul life. We hold that the subconscious world is nearer the Gates of Paradise than the intellectual world built upon a substructure of logical inference. We maintain that the revelations which reach the conscious world via the subconscious are truer glimpses of the Life Eternal than the manufactured products of the logical laboratories. Hence we regard the assurance of immortality as a God-given endowment to the subconscious phase of soul life. This eternal verity, known as such to subconsciousness, therefore appears in consciousness as a persistent and necessary intuitionial truth which finds no definite point of entry in the scheme of logic. Immortality finds its place as the complement of the intent of reality. Logic and reason cannot determine the type or form which this fuller experience will assume beyond death. The link of personal recollections is not shattered by death. In the fuller life our demand for a growing and higher experience will find its satisfaction.

CONCLUDING REMARKS

Looking in retrospect upon the matter presented in this work, we fully realize that a mere suggestive outline of possibilities has been presented. It is our hope that sufficient possibilities have been outlined to interest others in the further development of this spiritual concept of the physical universe.

We have found that the Spirit of God manifests in the microcosm and in the macrocosm, in the unconscious as well as in the subconscious and conscious, in the monon and viton as well as in the most complex form of mental life. The world is a created revelation of a Timeless Reality in temporal finiteness. The intent of this Timeless Reality deferred in time leaves the imprint of purpose and teleology throughout the universe. The temporal desire for harmony with the Timeless Reality is a world teleology which points toward Absolute Truth, Absolute Freedom, and the Harmony of Finite Being with the Life of God.

APPENDIX A

A NON-NEWTONIAN DEVELOPMENT OF THE PLANETARY ORBITS

125. The Planetary Orbits According to the Space-Time Potential.

In our development of the planetary orbits we shall make use of no other relations than those set forth in statics and dynamics. Moreover, we shall make no use of the Newtonian inverse square hypothesis. The central force notion of Newton we shall abandon for an assumption which contains within itself a sufficient physical reason for an orbit of unequal axes. A single constant central force contains within itself no physical reason to account for such a modification of a circular orbit. In the plane of the orbit we shall introduce two unequal force factors acting in a two-directional manner. Moreover, we shall assume that space is a sense chart of position values in such a manner that the location of a thing in space is determined by the directional intensity of the interaction at the particular position. Furthermore, we shall suppose that space is not an obstacle to interaction, but a measure of the relative intensity. These are the basic suppositions of our Space-Time Potential in accordance with which we shall now investigate the orbital motion of a body in a plane of space.

Let the components of the activity intensities in any given plane AA of space, chosen, for the sake of convenience, at right angles to each other, be of equal magnitude, then the intensity of the action or stress upon any plane BB perpendicular to the given plane AA and making any angle whatsoever with the direction of the components, will be of equal magnitude. In other words, the resultant of the tangential and normal stresses on the plane BB will be equal to the resultant of these stresses if plane BB is revolved into any other position CC .

A body free to move in a plane AA subjected to such activity conditions will move in a circular orbit and will be

in dynamic equilibrium in this orbit. The radius r of this orbit will remain a constant equal to the initial radius observed for the given body assumed to move in the plane AA .

If the observed orbit is not circular, then the stress components are unequal in magnitude.

If the stress components are unequal, then the orbit of the body is a conic section. The type of the conic depends upon the relative magnitude of the stress intensities.

We shall now investigate the activity conditions prevailing in a plane subjected to a two-directional stress system of unequal intensities.

For purposes of analysis let us take any plane AAA_1A_1 , in space (see Fig. 16). The resultants of the activity factors outside of the limiting boundary of this particular space AAA_1A_1 may be reduced to the intensity factors F_y, F_y , equal in magnitude but opposite in direction; and F_x, F_x , also equal in magnitude and acting in opposite directions. As far as the plane AAA_1A_1 is concerned, the external activity factors are in equilibrium. This assumption is therefore in complete accord with the general procedure in dynamics as well as in statics. The general case of the above is when F_y is not equal to F_x .

In Fig. 17 we have resolved the intensity factor F_y into a tangential component T_y , and a normal component N_y , with reference to the plane BB .

In the triangle PQR we have

$$\sin \beta = \frac{N_y}{F_y} \quad \text{and} \quad N_y = F_y \cdot \sin \beta.$$

Similarly,

$$\cos \beta = \frac{T_y}{F_y} \quad \text{and} \quad T_y = F_y \cdot \cos \beta.$$

Since the axis XX is perpendicular to the direction of F_y , it follows that a unit area along XX corresponds to an area along BB found from the following relation:

$$\sin \beta = \frac{A_x}{A_B}, \quad \text{hence} \quad A_B = \frac{A_x}{\sin \beta}.$$

Now since $A_x = 1$, it follows that the corresponding area along BB is given by

$$A_B = \frac{1}{\sin \beta}.$$

If I = intensity of the action per unit of area upon any plane BB and f = the magnitude of this action upon an area A_B , it follows that

$$I = \frac{f}{A_B}.$$

Hence it is clear that the unit area intensity of the normal component N_y , along BB is expressed by

$$N_y = \frac{F_y \cdot \sin \beta}{1 \div \sin \beta}; \text{ because } A_B = 1 \div \sin \beta.$$

Consequently,

$$N_y = F_y \cdot \sin^2 \beta.$$

Similarly, we have for the unit area intensity of the tangential component T_y , along BB ,

$$T_y = \frac{F_y \cdot \cos \beta}{1 \div \sin \beta} = F_y \cdot \cos \beta \cdot \sin \beta.$$

Referring to Figures 17 and 18, we find that N_y and N_x act in the same direction, while T_y and T_x act in opposite directions. If we regard the components of F_y as positive, then N_x is positive and T_x is negative.

Considering a unit area along YY , we have in the same manner as above,

$$\begin{aligned} \sin(90^\circ - \beta) &= \frac{A_y}{A_B}, \quad A_B = \frac{A_y}{\sin(90^\circ - \beta)} \\ &= \frac{1}{\sin(90^\circ - \beta)} = \frac{1}{\cos \beta}. \end{aligned}$$

Moreover, from triangle PLM we find

$$\cos \beta = \frac{+N_x}{F_x} \quad \text{and} \quad N_x = +F_x \cdot \cos \beta.$$

Furthermore, we obtain the relation

$$\sin \beta = \frac{-T_x}{F_x} \quad \text{and} \quad T_x = -F_x \cdot \sin \beta.$$

For unit area intensities we have

$$N_x = +\frac{F_x \cdot \cos \beta}{1 \div \cos \beta} = +F_x \cdot \cos^2 \beta \quad \text{and}$$

$$T_x = -\frac{F_x \cdot \sin \beta}{1 \div \cos \beta} = -F_x \cdot \sin \beta \cdot \cos \beta.$$

The negative sign has been introduced here since T_x acts in a direction opposite to T_y . Combining similar components of F_y and F_x , we obtain

$$\begin{aligned} N \text{ (the total normal component)} &= N_y + N_x, \\ &= F_y \cdot \sin^2 \beta + F_x \cdot \cos^2 \beta \end{aligned}$$

T (the total tangential component)

$$\begin{aligned} &= T_y + T_x \\ &= F_y \cdot \cos \beta \cdot \sin \beta - F_x \cdot \sin \beta \cdot \cos \beta, \\ &= \sin \beta \cdot \cos \beta (F_y - F_x). \end{aligned}$$

In Fig. 19 the resultant R of N and T is given by the line PV . It is evident that

$$R = \sqrt{N^2 + T^2}.$$

Substituting the values of N and T in this equation, we have

$$\begin{aligned} R &= \sqrt{(F_y \cdot \sin^2 \beta + F_x \cdot \cos^2 \beta)^2 + (\sin \beta \cdot \cos \beta (F_y - F_x))^2} \\ &= \sqrt{(F_y \cdot \sin^2 \beta + F_x \cdot \cos^2 \beta)^2 + (\sin^2 \beta \cdot \cos^2 \beta (F_y - F_x))^2} \\ R &= \sqrt{F_y^2 \{\sin^4 \beta + \sin^2 \beta \cdot \cos^2 \beta\} + F_x^2 \{\cos^4 \beta + \sin^2 \beta \cdot \cos^2 \beta\}} \\ &\quad + 2F_y \cdot F_x \{\sin^2 \beta \cdot \cos^2 \beta - \sin^2 \beta \cdot \cos^2 \beta\}. \end{aligned}$$

Since $\{\sin^2 \beta \cdot \cos^2 \beta - \sin^2 \beta \cdot \cos^2 \beta\} = 0$, the expression becomes

$$\begin{aligned} R &= \sqrt{F_y^2 \{\sin^4 \beta + \sin^2 \beta \cdot \cos^2 \beta\} + F_x^2 \{\cos^4 \beta + \sin^2 \beta \cdot \cos^2 \beta\}} \\ &= \sqrt{F_y^2 \cdot \sin^2 \beta \{\sin^2 \beta + \cos^2 \beta\} + F_x^2 \cdot \cos^2 \beta \{\cos^2 \beta + \sin^2 \beta\}}. \end{aligned}$$

The value $(\sin^2 \beta + \cos^2 \beta) = 1$, consequently the last expression reduces to

$$R = \sqrt{F_y^2 \cdot \sin^2 \beta + F_x^2 \cdot \cos^2 \beta}. \quad (\text{In Fig. 19, } R = PV.)$$

The resultant R makes the angle φ with the plane BB .

This is evident from Fig. 19, from which we see that

$$\tan \varphi = \frac{N}{T}. \quad (\angle BPV = \angle PVW = \varphi).$$

By substituting the values of N and T in this equation we have

$$\tan \varphi = \frac{F_y \cdot \sin^2 \beta + F_x \cdot \cos^2 \beta}{\sin \beta \cdot \cos \beta (F_y - F_x)}$$

If we divide both numerator and denominator of this last expression by $\cos^2 \beta$, we obtain

$$\tan \varphi = \frac{\frac{F_y \cdot \sin^2 \beta}{\cos^2 \beta} + \frac{F_x \cdot \cos^2 \beta}{\cos^2 \beta}}{\frac{\sin \beta \cdot \cos \beta}{\cos^2 \beta} \{F_y - F_x\}} = \frac{F_y \cdot \tan^2 \beta + F_x}{\tan \beta \{F_y - F_x\}}.$$

In Fig. 19, let $\theta =$ angle between PV (i. e. R) and PZ (the direction of F_y). The following relation holds good:

$$\theta = (\beta - \varphi)$$

Consequently,

$$\tan \theta = \tan(\beta - \varphi) = \frac{\tan \beta - \tan \varphi}{1 + \tan \beta \cdot \tan \varphi}.$$

If we substitute the value of $\tan \phi$ obtained above in this last expression we have

$$\begin{aligned}\tan \theta &= \frac{\tan \beta - \frac{F_y \cdot \tan^2 \beta + F_x}{\tan \beta (F_y - F_x)}}{1 + \tan \beta \left\{ \frac{F_y \cdot \tan^2 \beta + F_x}{\tan \beta (F_y - F_x)} \right\}} \\ &= \frac{\tan^2 \beta \cdot F_y - \tan^2 \beta \cdot F_x - \tan^2 \beta \cdot F_y - F_x}{\tan \beta [(F_y - F_x) + \{F_y \cdot \tan^2 \beta + F_x\}]} \\ &= \frac{-\tan^2 \beta \cdot F_x - F_x}{\tan \beta \cdot F_y + \tan \beta (F_y \cdot \tan^2 \beta)} = \frac{-F_x(1 + \tan^2 \beta)}{\tan \beta \cdot F_y (1 + \tan^2 \beta)}\end{aligned}$$

Hence,

$$\tan \theta = -\frac{F_x}{F_y \cdot \tan \beta} = -\frac{F_x}{F_y} \cdot \cot \beta.$$

Let $y = F_y \cdot \sin \beta$ and $x = F_x \cdot \cos \beta$; then, since

$$\begin{aligned}R &= \sqrt{F_y^2 \cdot \sin^2 \beta + F_x^2 \cdot \cos^2 \beta} \\ R^2 &= y^2 + x^2.\end{aligned}$$

This equation, being of the second degree, is a conic section.

Let the coördinates of any point D on this curve (see Fig. 20) be x, y . To construct the conic, proceed as follows: With point P as a center, describe the outer circle with a radius F_y . Similarly, draw the inner circle with a radius F_x , since F_y has been assumed greater than F_x .

Any point D on the curve of the conic must satisfy the relation $R^2 = y^2 + x^2$.

$$\begin{aligned}\text{Take } PH &= x = F_x \cdot \cos \beta \quad \text{and} \\ PE &= y = F_y \cdot \sin \beta,\end{aligned}$$

where angle β is the angle which the plane BB makes with the Y axis.

These values of x and y determine any point D of the curve.

We may locate any point D of the curve by the following method: In Fig. 20, PC is constructed perpendicular to the plane BB . From the point C where PC intersects the outer circle, line CE is constructed perpendicular to the Y axis and consequently parallel to the X axis. From the point of intersection G of PC and the inner circle, line FG is drawn parallel to the X axis. Also from point G , line GD is made parallel to the Y axis. The intersection of lines GD and CE determines the point D in the curve. Moreover, the line PD ,

connecting points P and D , is the radius vector of the curve, and it is commensurate with R , the resultant stress upon the plane BB . Furthermore, the direction of line PD represents the inclination of the resultant stress to the plane BB . That this construction satisfies the relations

$$y = F_y \cdot \sin \beta, \text{ and } x = F_x \cdot \cos \beta$$

will now be shown.

In Fig. 20, the construction is such that

$$PC = F_y; PG = F_x; PE = y; \text{ and } FG = ED = x.$$

Moreover, the following relations are true:

$$\text{angle } CPE = (90^\circ - \beta), \text{ and}$$

$$\cos(90^\circ - \beta) = \frac{PE}{PC}; \quad PE = PC \{\cos(90^\circ - \beta)\} = F_y \cdot \sin \beta = y;$$

$$\sin(90^\circ - \beta) = \frac{FG}{PG}; \quad FG = PG \{\sin(90^\circ - \beta)\} = F_x \cdot \cos \beta = x.$$

It is evident that

$$\overline{PD}^2 = \overline{PE}^2 + \overline{ED}^2, \text{ and, consequently,} \\ R^2 = y^2 + x^2 = F_y^2 \cdot \sin^2 \beta + F_x^2 \cdot \cos^2 \beta.$$

Furthermore,

$$\tan \angle DPE = \frac{ED}{PE} = \frac{F_x \cdot \cos \beta}{F_y \cdot \sin \beta} = \frac{F_x}{F_y} \cdot \cot \beta.$$

We have seen that

$$-\frac{F_x}{F_y} \cdot \cot \beta = \tan \theta, \text{ therefore}$$

$$\tan \angle DPE = \tan \theta, \text{ and } \angle DPE = \angle \theta.$$

In Fig. 20 the resultant $PD = R$ is in the first quadrant, and the inclination angle φ which it makes with the plane BB is therefore greater than angle β , consequently,

$$\varphi = \theta + \beta \quad \text{and} \quad \theta = (\varphi - \beta).$$

Hence $\tan \theta = \tan(\varphi - \beta)$. By proceeding as above we find that

$$\tan(\varphi - \beta) = +\frac{F_x}{F_y} \cdot \cot \beta.$$

which is the same value as obtained for $\tan(\beta - \varphi)$ with the opposite algebraic sign.

Hence

$$\tan \theta = +\frac{F_x}{F_y} \cdot \cot \beta.$$

Consequently, the construction satisfies the necessary conditions imposed by the fundamental relations previously developed.

We shall now prove that the extremity of the radius vector R traces a conic. Referring again to Fig. 20, we find that

$$\frac{F_x^2}{F_y^2} = \frac{\overline{PG}^2}{\overline{PC}^2} = \frac{\overline{FG}^2}{\overline{CE}^2} = \frac{\overline{DE}^2}{\overline{CE}^2} = \frac{x^2}{CE^2}, \text{ since } FG = DE;$$

but $\overline{CE}^2 = LE(KE)$; therefore

$$\frac{F_x^2}{F_y^2} = \frac{x^2}{LE(KE)}.$$

Since $KE = (F_y - y)$ and $LE = (F_y + y)$, it follows that

$$\frac{F_x^2}{F_y^2} = \frac{x^2}{(F_y + y)(F_y - y)} = \frac{x^2}{(F_y^2 - y^2)},$$

which gives

$$\begin{aligned} F_x^2(F_y^2 - y^2) &= F_y^2 \cdot x^2, \text{ or} \\ F_y^2 x^2 + F_x^2 y^2 &= F_y^2 \cdot F_x^2, \end{aligned}$$

which is the equation of a conic.

If the terms of this expression be divided by $F_x^2 \cdot F_y^2$, we obtain the equation in its most easily recognized form as follows:

$$\frac{x^2}{F_x^2} + \frac{y^2}{F_y^2} = 1.$$

In this form we readily recognize the conic as an ellipse. It is apparent that the type of the conic depends upon the relative magnitude of the activity factors F_x and F_y . If these factors are equal to each other, the conic becomes a circle. If they are unequal in magnitude, the curve is an ellipse which tends toward a parabola when the ratio of their intensities approaches an infinite value. Conversely, if the orbit is an ellipse, the activity factors prevailing in the plane of the orbit are unequal in their magnitude. For negative values of F_y^2 the curve becomes an hyperbola.

An exhaustive investigation of a material system interacting according to the Space-Time Potential involves a reference to a three-directional system of coördinate axes. The space of sense is most conveniently regarded as a triply extended manifold. The Newtonian hypothesis is primarily a one-directional vectorial system regarding the sun as a central force. The one-directional attraction between the sun and the earth is, according to Newton, a sufficient reason for the earth's orbit type. We cannot agree with this convenient simplification, for the reason that any finite portion of a plane in space must be under the influence of a two-directional activity system. In this manner only are we able

to include all the activity factors within the plane beyond the confines of the finite portion considered. By referring the finite portion to an X and a Y axis all activity factors in the plane will be either above or below the X axis and to the left or the right of the Y axis.

We conclude, from the above mathematical analysis, that a body free to move under the action of the unequal forces F_y and F_x in the plane AAA_1A_1 , will describe a locus consistent with the requirements that the resultant R of the unequal activity factors shall, for all points of the locus, satisfy the relation

$$R = \sqrt{F_y^2 \cdot \sin^2 \beta + F_x^2 \cdot \cos^2 \beta}.$$

That the locus is a conic section has already been shown.

We shall now supplement the above statical analysis by two additional proofs based upon the laws of dynamics. It is to be noted that the Newtonian inverse square hypothesis has been discarded.

126. The Keplerian Relations according to the Space-Time Potential.

Let us now consider the problem from another stand-point. In Fig. 21, let the radius PR of the inner circle RG_1A be commensurate with a force F_x , and let the radius PK of the outer circle KC_1B be commensurate with a force F_y . The distance RK is then commensurate with $(F_y - F_x)$. Let point N be the mid-point of the distance RK and let $e = RN = NK$. The circle NN_1N_2 passing through point N and having P as its center is then the mid-locus of the ring area $KBAR$. The length $RN = NK = e$. is therefore commensurate with $(F_y - F_x) \div 2$, and the locus NN_1N_2 may be regarded as a neutral locus. In order that the action which we are about to investigate may be easily understood we shall imagine that the body is connected to the origin P by a resistive spiral spring. At first we shall confine the direction of the motion of the body to the line RK . Moreover, we shall assume that initially the body is located at the mid-point N in the neutral locus NN_1N_2 . The movable body may then be displaced through the distance NK whenever it comes under the periodic influence of the outward acting force $-(F_y - F_x) \div 2$. We use the negative sign in con-

nexion with this outward force in order to distinguish the direction from the $(F_y - F_z) \div 2$, which we consider as being directed toward the origin P . The periodic displacement of the body through NK against the inward resistive force $(F_y - F_z) \div 2$ is much the same as if the body were periodically seized by an external agent and dragged through this distance against the resistive force of a spring. The path RK may be regarded as a smooth, frictionless slide or plane surface upon which the body can oscillate. Our preliminary investigation will confine the body to an oscillatory motion along this slide.

Let the force required to displace the body a unit distance along the vector against the resistive force $(F_y - F_z) \div 2$, regarded as acting toward P , be represented by f . The total force F_e necessary to displace the body through the distance $NK = e$ is then $f \cdot e = F_e$. Suppose, now, that the body has been brought to the point K by the action of the outward force $(F_y - F_z) \div 2 = F_e$. Upon the cessation of the activity of F_e , which we can properly assume at this stage of the analysis, the body begins its return motion in a direction toward point P . When it has moved through a distance $i = KM$ it has arrived at any general point M .

At the point M the available force F_z is commensurate with the remaining distance to N ; that is, the distance $MN = (e - i) = z$. Hence

$$F_z = f \cdot z = f(e - i).$$

If for the body at any general point M we let

v = velocity,

a = acceleration, and

m = the mass then

$$v = \frac{di}{dt}, \quad a = \frac{dv}{dt}, \quad \text{and} \quad v \, dv = a \, di$$

At the point M the available force $F_z = f(e - i) = m \cdot a$

and $a = \frac{f(e - i)}{m}$.

Substituting this value of a in $v \, dv = a \, di$, we have

$$v \, dv = \frac{f(e - i)}{m} \cdot di$$

Integrating from o to v and from o to i , we obtain

$$\int_o^v v \, dv = \int_o^i \frac{f(e-i)}{m} \cdot di,$$

$$\frac{v^2}{2} = \frac{f}{m} \int_o^i (e-i) \cdot di = \frac{f}{m} \int_o^i (e \cdot di - i \cdot di)$$

$$\frac{v^2}{2} = \frac{f}{m} \left\{ ei - \frac{i^2}{2} \right\}, \text{ and } v^2 = \frac{2f}{m} \left\{ ei - \frac{i^2}{2} \right\} = \frac{f}{m} \left\{ 2ei - i^2 \right\},$$

which gives

$$v = \sqrt{\frac{f}{m} \cdot \left\{ 2ei - i^2 \right\}^{\frac{1}{2}}}.$$

An inspection of this last equation reveals the fact that $v=0$ when $i=e$, or when $i=2e$; consequently the body will oscillate between the points K and R .

When $i=e$, v has a maximum value given by

$$v_{\max} = \sqrt{\frac{f}{m} \cdot \left\{ 2e^2 - e^2 \right\}^{\frac{1}{2}}} = e \sqrt{\frac{f}{m}}.$$

Since $v = \frac{di}{dt}$, $dt = \frac{di}{v}$, and therefore $\int dt = \int \frac{di}{v}$.

$$\int_o^t dt = \int_o^{2e} \frac{di}{v} = \int_o^{2e} \frac{di}{\sqrt{\frac{f}{m} \cdot \left\{ 2ei - i^2 \right\}^{\frac{1}{2}}}} = \sqrt{\frac{m}{f}} \int_o^{2e} \frac{di}{\sqrt{\left\{ 2ei - i^2 \right\}^{\frac{1}{2}}}},$$

where t is the time required for the body to traverse the distance $2e$.

$$\text{Now, } \int \frac{di}{\sqrt{2ei - i^2}} = \text{arc ver sin} \left(\frac{i}{e} \right).$$

If in Fig. 21 the circle KHR be described with NK as a radius, then in the triangle NMH we have

$$\text{ver sin } \delta = 1 - \cos \delta = \frac{(NH - MN)}{NH};$$

but

$$(NH - MN) = (NK - NM) = (e - z) = e - (e - i) = i.$$

Therefore, $\text{ver sin } \delta = \frac{i}{e}$, and it follows that δ is the arc whose $\text{ver sin} = \frac{i}{e}$. It is also evident that

$$\int_o^t dt = \sqrt{\frac{m}{f}} \cdot \text{arc ver sin} \left[\frac{i}{e} \right]_o^{2e}$$

The motion of the body from point $K = o$ to point R over the path $KR = 2e$ corresponds to a variation of the angle δ from 0° to 180° . In circular measure, since the radians in $1^\circ = \pi \div 180^\circ$; we have $\delta = \pi$, when δ is measured in degrees $= 180^\circ$. These values correspond to a value of $i = 2e$. From these observations the following relation should be self-evident:

$$\int_0^t dt = \pi \sqrt{\frac{m}{f}} = t.$$

It is seen that in the circle KHR the ordinate drawn from any position M of the body moving in the path of KR intercepts an arc KH which determines the instantaneous value of δ .

The general expression (circular measure) for t , the time, is therefore

$$t = \delta \sqrt{\frac{m}{f}}.$$

Investigating the dynamic relations pertaining to the moving point M in the rectilinear path KR and the point H in the circular path KHR , we find, for the point M moving in KR , the following expression for velocity, acceleration, time, etc., corresponding to simultaneous positions of H :

$$1. \quad \text{ver} \sin \delta = (1 - \cos \delta) \div 1 - \left(\frac{e-i}{e} \right) = \frac{i}{e}$$

$$2. \quad i = e \cdot \text{ver} \sin \delta = e(1 - \cos \delta)$$

$$3. \quad t = \delta \sqrt{\frac{m}{f}}$$

Since $di = d\{e(1 - \cos \delta)\} = e \cdot \sin \delta \cdot d(\delta)$, and

$$dt = \sqrt{\frac{m}{f}} \cdot d(\delta);$$

then, if we substitute these values in the general expression

$$v = \frac{di}{dt}, \text{ we have}$$

$$4. \quad v = \frac{di}{dt} = \frac{e \cdot \sin \delta \cdot d(\delta)}{\sqrt{\frac{m}{f}} \cdot d(\delta)} = \sqrt{\frac{f}{m}} \cdot e \sin \delta$$

$$5. \quad a = \frac{f(e-i)}{m} = \frac{f}{m} \cdot e(\cos \delta).$$

This is evident because $(e-i) = e(\cos \delta)$.

From Equation 3 we have $t = \delta \sqrt{\frac{m}{f}}$, consequently

$$dt = d(\delta) \sqrt{\frac{m}{f}}$$

and

$$6. \quad d(\delta) = dt \cdot \sqrt{\frac{f}{m}}.$$

$$7. \quad \frac{d(\delta)}{dt} = \sqrt{\frac{f}{m}} = \text{angular velocity} = \mu.$$

In Fig. 21 $z = (e-i) = NM = e \cdot \cos \delta$, hence the following:

$$8. \quad dz = -e \cdot \sin \delta \cdot d(\delta).$$

$$9. \quad d^2z = -e \cdot \cos \delta (d\delta)^2 = -z \cdot (d\delta)^2;$$

but since

$$\frac{d(\delta)}{dt} = \mu, \quad d(\delta) = \mu \cdot dt, \quad \text{and}$$

$$d^2z = -z \cdot (\mu \cdot dt)^2,$$

hence

$$10. \quad \frac{d^2z}{dt^2} + \mu^2 \cdot z = 0.$$

From Equation 7 we observe that μ the angular velocity is constant. In other words, the rate of increase of δ is uniform, and the point H travels in its circular orbit KHR about point N as a center at a uniform rate.

Equation 10 may be developed as follows, using point N as the origin:

Let arc $KH = h$, then in circular measure $\delta = \frac{h}{e}$.

When the body is at K the time is represented by t_0 , and when it is at any point H in the circular orbit, the time is t ; hence the time required in the passage from K to H is $(t - t_0)$. Knowing from the above discussion that v is constant, we have

$$v = \frac{h}{(t - t_0)}, \quad \text{and} \quad h = v(t - t_0).$$

From the figure we see that

$$\begin{aligned} z &= e \cdot \cos \delta = e \cdot \cos \left(\frac{h}{e} \right) = e \cdot \cos \left\{ \frac{v}{e} (t - t_0) \right\}, \\ &= e \cdot \cos \left\{ \frac{v}{e} \cdot t - \frac{v}{e} \cdot t_0 \right\}. \end{aligned}$$

Since

$$\mu = \frac{d(\delta)}{dt} = \frac{d\left(\frac{h}{e}\right)}{dt} = \frac{\frac{1}{e} d(vt)}{dt} = \frac{v}{e} (\text{a constant});$$

therefore we have by letting

$$v = -\frac{v}{e} \cdot t_0 = -\mu \cdot t_0,$$

$$11. \quad z = e \cdot \cos \{\mu \cdot t - \mu \cdot t_0\} = e \cdot \cos \{\mu(t - t_0)\} \\ = e \cdot \cos \{\mu \cdot t + v\}.$$

The velocity v_s of the body along the rectilinear path KR is expressed by $v_s = \frac{dz}{dt}$ and

$$v_s = \frac{dz}{dt} = \frac{d[e \cdot \cos \{\mu t + v\}]}{dt} = \frac{-e \cdot \sin \{\mu t + v\} \cdot d\{\mu t + v\}}{dt},$$

but since, $d\{\mu t + v\} = \mu \cdot dt$, it follows that

$$12. \quad v_s = \frac{-e \cdot \sin \{\mu t + v\} \mu \cdot dt}{dt} = -e \cdot \mu \cdot \sin \{\mu t + v\}.$$

Let a = the acceleration of M along KR , then

$$13. \quad a = \frac{d^2z}{dt^2} = -e \cdot \mu^2 \cdot \cos \{\mu t + v\}, \text{ and since}$$

$z = e \cdot \cos \{\mu t + v\}$, by substitution we obtain

$$14. \quad a = \frac{d^2z}{dt^2} = -\mu^2 \cdot z, \text{ or } \frac{d^2z}{dt^2} + \mu^2 \cdot z = 0.$$

This equation is identical with Equation 10.

Dividing both members of Equation 14 by z , we have

$$15. \quad \frac{a}{z} = -\frac{\mu^2 \cdot z}{z} = -\mu^2 \text{ (a negative constant).}$$

By using the transformation formula

$$\cos(a+b) = \cos a \cdot \cos b - \sin a \cdot \sin b \text{ in}$$

Equation 11, we obtain

$$16. \quad z = e \cdot \cos \{\mu t + v\} = e[\cos \mu t \cdot \cos v - \sin \mu t \cdot \sin v];$$

and letting

$$T = -e \cdot \sin v, \text{ and } U = +e \cdot \cos v,$$

we can reduce Equation 16 to the general form for simple harmonic motion, viz.;

$$17. \quad z = T \cdot \sin \mu t + U \cdot \cos \mu t = e \cdot \cos \{\mu t + v\}.$$

If p is the period of one complete oscillation = $2(KR)$ and corresponding to a value of $\delta = 360^\circ = 2\pi$ (circular measure) we have, since

$$t = \delta \sqrt{\frac{m}{f}} \quad (\text{see Equation 3}),$$

$$t = \frac{2\pi}{\sqrt{\frac{f}{m}}} = \frac{2\pi}{\mu}, \text{ for by Equation 7, } \mu = \sqrt{\frac{f}{m}}.$$

Moreover, in the above expression e is the amplitude, and since

$$+\frac{v}{\mu} = \left\{ -\frac{vt_0}{e} \div \frac{v}{e} \right\} = -t_0,$$

the phase

$$t_0 = -\frac{v}{\mu}.$$

The law expressed by Equation 10 is equally the law of electric oscillations if the resistance is neglected. If we let v be the electromotive force of the system, measured in volts, we have

$$\frac{d^2v}{dt^2} + \mu^2 \cdot v = 0, \text{ where } \mu \text{ is a constant.}$$

Thus far we have investigated the dynamics of the body for a motion confined to the rectilinear path KR . We have seen that if the motion of the body be defined by the motion of H in the circular orbit KHR , then H will describe equal arcs in equal time, and the angular velocity of the vector NH will be constant. We shall now make the further assumption that the vector KRP rotates about P as a center, and that simultaneously with this motion the body moves with a constant angular velocity μ about the origin N as a center. At the end of a definite interval of time t_1 , the vector is in the position PG_1C_1 . We shall, moreover, consider that the path or orbit of the body is at all times controlled by two forces, one parallel to the X axis and the other parallel to the Y axis. Furthermore, we shall investigate the case in which these forces, acting in normal directions to each other, have for their resultant a constant magnitude =

$$\frac{2(F_y - F_x)}{2} = 2(NK) = KR = (F_y - F_x).$$

The motion of the body is, therefore, confined to the ring area $RKBA$.

In triangle $G_1C_1D_1$ (Fig. 21) the following relation is evident:

$$\overline{G_1C_1}^2 = \overline{C_1D_1}^2 + \overline{D_1G_1}^2.$$

Let us designate the involved magnitudes as follows:

f_x = force parallel to the X -axis.

f_y = force parallel to the Y -axis,

$F = (F_y - F_x)$ = resultant = a constant.

We may then write for any position of the vector PK ,

$$F^2 = (f_x)^2 + (f_y)^2 = (F_y - F_x)^2.$$

At any point D_1 the forces f_x and f_y may be resolved normally and tangentially to the direction of motion. It is evi-

dent that if this is done the sum of the squares of these force components must equal $(f_x)^2 + (f_y)^2 = F^2 = \text{a constant}$.

In the triangle $G_1C_1D_1$ we have

$$C_1D_1 = MC_1 - MD_1 = F_y \cdot \cos \beta_1 - F_x \cdot \cos \beta_1 = (F_y - F_x) \cos \beta_1, \text{ and}$$

$$D_1G_1 = D_1J - G_1J = F_y \cdot \sin \beta_1 - F_x \cdot \sin \beta_1 = (F_y - F_x) \sin \beta_1.$$

But since $\overline{D_1G_1}^2 + \overline{C_1D_1}^2 = \overline{C_1G_1}^2 = F^2$, we have

$$F^2 = (F_y - F_x)^2 \cdot \sin^2 \beta_1 + (F_y - F_x)^2 \cdot \cos^2 \beta_1;$$

therefore

$$F^2 = (F_y - F_x)^2,$$

which is identical with our original assumptions, and it follows that the coördinates of point D_1 , with P as the origin, are

$$x = MD_1 = F_x \cdot \cos \beta_1 \text{ and}$$

$$y = D_1J = F_y \cdot \sin \beta_1.$$

Consequently the locus of points satisfying the condition $F^2 = (f_x)^2 + (f_y)^2 = \text{a constant}$ and described as shown is a conic. This should be evident from the previous developments.

In Fig. 21 it is evident that as the vector rotates $\angle \alpha_1$ of any triangle $G_1C_1D_1 = \angle KPC_1 =$ the vectorial angle.

Moreover, $\angle \alpha_1 = \angle D_1G_1C_1$ is measured by one half arc C_1D_1 , and the central angle D_1nC_1 is measured by arc C_1D_1 .

Consequently $\angle D_1nC_1 = 2\alpha_1 = \delta_1$. By Equation 7 we know that our primary suppositions gave us a constant angular velocity for the body actuated by the assumed force factors.

In other words, $\frac{d(\delta)}{dt} = \text{a constant}$, being a consequence of the force activities assumed primarily; therefore, the continuity of this condition, taken in conjunction with the rotation of the vector, means that the sub-vector D_1n will describe equal arcs in equal times, and the rate of increase of

$$2\alpha_1 = \delta_1 \quad \text{is uniform.}$$

From this fact we conclude that since

$$\frac{d(\delta)}{dt} = \frac{d\{2(\alpha)\}}{dt} = \text{a constant, therefore}$$

$\frac{d(\delta)}{dt}$ also is a constant, which means that if F^2

shall equal $\{f_x^2 + f_y^2\} = \text{a constant}$, the angular velocity of the vector PC_1 must also be constant, because to satisfy this condition the principal vector PC_1 must always describe the angle

$$\alpha_1 = \frac{1}{2} \angle D_1nC_1 = \frac{1}{2}(2\alpha_1).$$

The vector PC_1 , therefore, describes equal angles in equal times. The converse may readily be shown to be true; that is, if the vector describes equal angles in equal times the locus is a conic.

An important deduction may be made from the above conclusions. Since the area A of the elliptic sector KD_1P is given by

$$A = \pi \cdot PK \cdot PA \left(\frac{\alpha_1}{360^\circ} \right) = \frac{PK \cdot PA \cdot \alpha_1}{2} \left(\frac{\pi}{360^\circ} \right), \text{ where}$$

$\pi \div 180^\circ$ = radians in 1° , it follows that in circular measure, with α_1 given in radians,

$$A = \frac{F_y \cdot F_x}{2} (\alpha_1);$$

and since

$$\frac{F_y \cdot F_x}{2}$$

is a constant, the area described by the elliptic vector PD_1 , depends upon and varies with the circular vectorial angle $KPC_1 = \alpha_1$. Since these circular vectorial angles are described in equal times, it follows that the elliptic vector PD_1 , describes equal areas in equal times. This is Kepler's law of areal velocities. It has been derived without the erroneous Newtonian central mass attraction idea, which hypothesis is incapable of showing a physical reason for the modification of the orbit from a circular into one of variable radial vectors. A single central force cannot produce this modification. In assuming the two unequal force factors F_y and F_x , we at the outset provide a physical basis for the mathematical results which follow.

We shall present the matter from still another standpoint. At the end of the time t_1 , we shall assume the vector PC_1 to be in the location shown in Fig. 21, with its vectorial angle = α_1 . We shall further suppose that the moving body is actuated by the outward acting forces — F_y and — F_x . Opposed to these forces are resistive inward-acting forces + F_y and + F_x , parallel respectively to the Y and X axes. These forces are constant. The moving body actuated by the two force factors is subjected to a simultaneous two-directional displacement whose limits are PK and PA , respectively commensurate with the forces F_y and F_x . Under

the action of these constant forces the body will be subjected simultaneously to an oscillatory displacement parallel to the Y and the X axes. The dynamic relations developed for the body in the orbit KHR will hold simultaneously for both forces because they are constants acting against resistive forces.

Let the body at the end of a period of time t_1 be found at point D_1 . Then, in respect to F_y , point D_1 must lie in a line C_1M parallel to the X — axis. In respect to the force F_x , point D_1 must lie in a line D_1J parallel to the Y —axis. The time of the quarter oscillation (complete period $\div 4$) PK is assumed equal to the time of the quarter oscillation PA .

Now, since

$$\frac{F_y}{F_x} = \frac{m \cdot \frac{v_y}{t}}{m \cdot \frac{v_x}{t}} = \frac{v_y}{v_x},$$

where v_y and v_x are the velocities of the body moving in the orbits KC_1B and RG_1A respectively.

But $\frac{v_y}{v_x} = \frac{s_y \div t}{s_x \div t}$, where s_y and s_x are the respective orbital arc distances. Consequently,

$$\frac{\text{arc } KC_1}{\text{arc } RG_1} = \frac{s_y}{s_x} = \frac{F_y}{F_x}.$$

This relation is true only when G_1 lies upon the vector C_1P . Therefore the line D_1J parallel to the Y axis must pass through point G_1 . It follows, therefore, in light of the previous disclosures, that D_1 is a general point in the conic which, in this case, is an ellipse. Moreover, the law of areal velocities is a direct consequence of the above relations.

We have referred to the fact that a complete investigation of any material system interacting according to the Space-Time Potential necessitates a reference to a three-directional system of axes.

The inclination of the earth's axis to the plane of its orbit shows conclusively that a third force factor influences the system. Since the obliquity of the ecliptic—that is, the angle between the plane of the ecliptic and the earth's equatorial plane—is about $23^\circ 27' 8''$, the angle which the earth's

axis makes with the ecliptic is about $66^{\circ} 32' 52''$. This angle is practically constant during the earth's elliptical motion in the plane of the ecliptic. Since the earth's semi-diameter (according to Bessel) is 20,923,597 feet, the distance h along a normal to the plane of the ecliptic from the most remote point of the earth's equatorial circumference is 8,327,260 feet. During one complete revolution of the earth about its axis this point traverses through a total normal distance $= 4h$ in the time 23 hours, 56 minutes, and 4 seconds $= 86,164$ seconds. For the distance h the time is 21,541 seconds. This corresponds to an acceleration $a = 0.035892 +$ feet per second squared, along the normal to the ecliptic, since $a = \frac{2h}{t^2}$. It is therefore clear that the obliquity of the ecliptic cannot be maintained without the continuous activity of a third directional force.

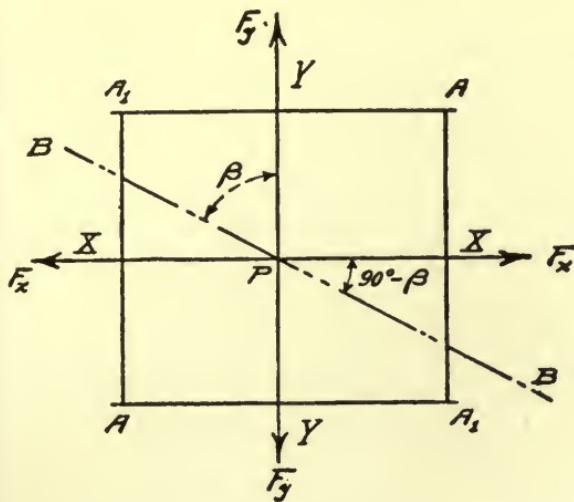


Fig. 16.

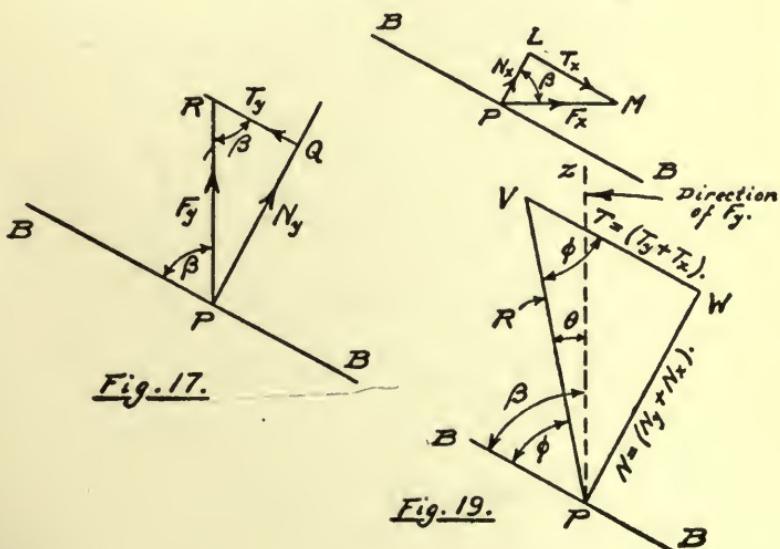


Fig. 17.

Fig. 18.

Fig. 19.

(9)

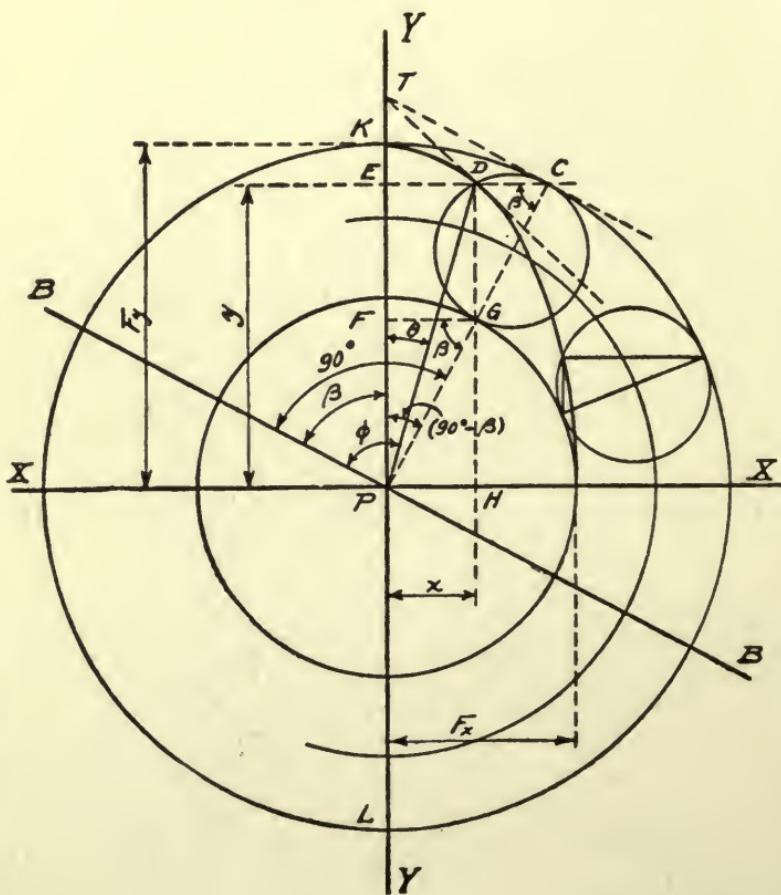
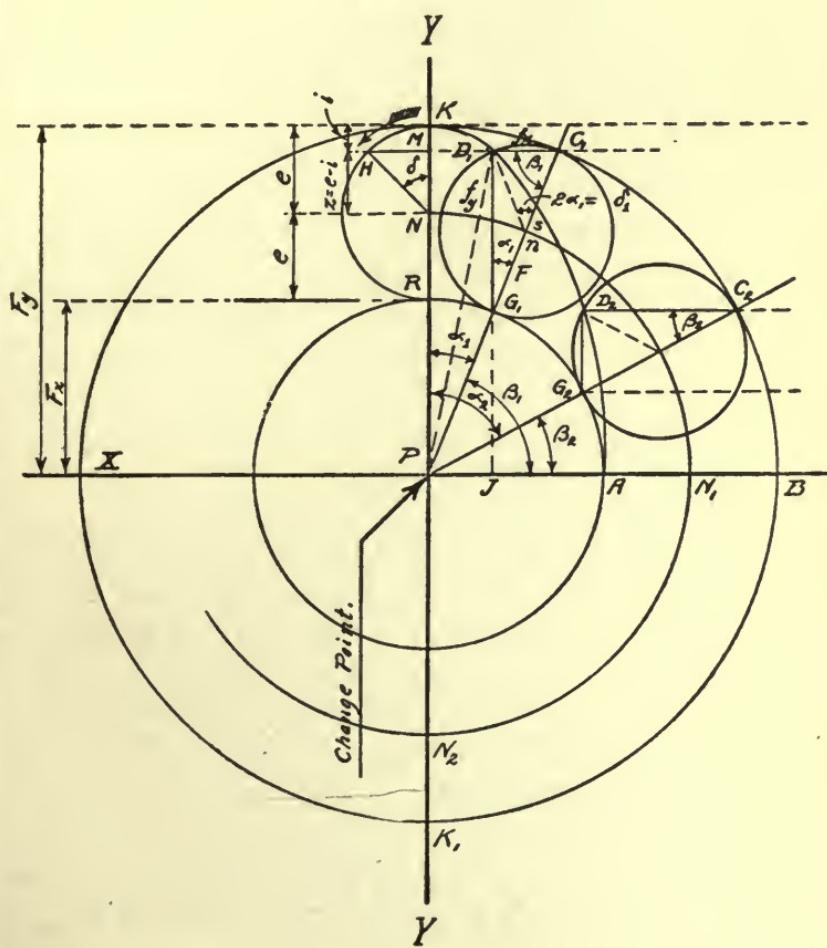
Fig. 20.

Fig. 21.

APPENDIX B

ELECTRICAL RELATIONS ACCORDING TO THE DYNAMICS OF THE SPACE-TIME POTENTIAL

127. The Newtonian Gravitational Relation According to Dynamics.

It is our purpose now to consider the Newtonian expression for gravitational attraction in connection with the requirements of dynamics.

Consider, then, the forces f and F acting at the two points A and C shown in Fig. 22. We use the term "force" here in its ordinary physical sense, without entering into the consideration of the implications involved. The work done in a system when a force f is transported through a distance r is given by the expression

$$W = f \cdot r$$

Therefore if the force f is transported to the point B through a distance $(s - x)$, the work $W_1 = f(s - x)$. In the same way the work W_2 performed in translating the force F to the point B through a distance x is given by $W_2 = F(x)$. Let us also assume that the point B is so related to the entire system that $W_1 = W_2 = f(s - x) = F(x)$. We can regard point B , then, as a neutral point in the system. Moreover, we shall suppose that the time t required to transport f to the point B is equal to the time t necessary to translate F from C to B . We can write the expression $F(x) = f(s - x)$ in the following manner:

$$f(s) = (F + f)x \quad \dots \dots \dots \quad (1)$$

$$\text{The acceleration } a \text{ of } f \text{ is therefore, } a = \frac{2(s-x)}{t^2} \quad \dots \dots \dots \quad (2)$$

$$\text{and the acceleration } b \text{ of } F \text{ is, } b = \frac{2x}{t^2} \quad \dots \dots \dots \quad (3)$$

It is evident that the above expressions for acceleration assume that f and F start simultaneously from rest. If the mass concentration at A is m , and at C, M , we have

Considering the system shown in Fig. 23, we there assume a mass concentration at A equal to the expression $\frac{Mm}{s^2}$, and similarly at C we locate a mass concentration of the same mathematical magnitude. The significance of this procedure will be apparent in the succeeding development. With these values for the mass concentration we obtain

$$f = \frac{Mm}{s^2}(a) \quad \text{and} \quad F = \frac{Mm}{s^2}(b).$$

Introducing the values for a and b given in Equations 2 and 3 into these expressions,

$$f = \frac{Mm}{s^2} \left\{ \frac{2(s-x)}{t^2} \right\} \quad \text{and} \quad F = \frac{M}{s^2} \left\{ \frac{2(x)}{t^2} \right\}$$

See Fig. 23.

Substituting these values of f and F in Equation 1, we have

$$f(s) = \left[\frac{Mm}{s^2} \left\{ \frac{2x}{t^2} \right\} + \frac{Mm}{s^2} \left\{ \frac{2(s-x)}{t^2} \right\} \right] \cdot x$$

Simplifying and solving the above expression for f we find,

$$f = \frac{2x}{t^2} \left[\frac{Mm}{s^2} \right] = b \left[\frac{Mm}{s^2} \right] \dots \dots \dots \quad (5)$$

Consequently, $f = F$; $a = b$, and $x = (s - x)$, and point B is the mid-point of the span AC .

The expression $b \left[\frac{Mm}{s^2} \right]$ is of the Newtonian type for two masses M and m at a distance s from each other.

Let us concentrate the mass m at A and M at C in the system shown in Fig. 22. Retaining the same values for accelerations and distances and proceeding as above, we now find for the value f the expression:

$$f = b \frac{\{M(x) + m(s-x)\}}{s} \dots \dots \dots (6)$$

In the above analysis we have used the fundamental equations of motion, force, and work, which can be shown

to be true by experimental evidence. We do not intend to abandon their use for the very reason that they can be experimentally verified. Their employment, in conjunction with the Newtonian expression, has brought us, however, face to face with a serious dilemma. We have derived Equation (5), which is in the Newtonian form, by employing these very fundamental and experimentally demonstrable laws of motion, force and work; nevertheless, the derived expression (Equation 5), according to Newton, should have been derived from the system shown in Fig. 22. The application of these same fundamental equations to the system shown in Fig. 22 gives us a radically different expression for f in Equation 6, involving the sum of the masses and the distance to the inverse first power. It is seen that Equation 5, the Newtonian type, can be correctly developed only under the assumption that the mass concentration is equal to the force divided by the acceleration, which is as it should be according to the fundamental laws of motion, force, and work. When we apply this relation between mass, acceleration, and force to the Newtonian system of Fig. 22, we derive an expression entirely foreign to the Newtonian conception.

128. The Fundamental Function of Non-Newtonian Dynamics.

Our interest, therefore, must be centered upon the more primitive function, the anti-differential of the Newtonian

$\frac{1}{8}$, variation, that is, the expression given by,

If we desire mechanically to reconstruct the universe, I feel certain that this can be most truthfully accomplished by thinking of interdependent activity centers as space-time projections of dynamic mass. To this space-time projection of interacting mass-acceleration kerns I have given the name of "space-time potential." This conception involves the postulate that every position in the universe has a definite potential coefficient and that displacement in the Space-Time Projection is commensurate with the magnitude

of the equilibrating readjustment involved in this activity. This view eliminates the ether as a necessary medium of propagation and communication of physical activities.

For reasons already stated, we abandon the Newtonian $\frac{1}{s^2}$ function and proceed to the investigation of its integral, the function which we maintain is the true function of activity variations in our interacting system made manifest in the Space-Time Potential.

Let A and B , Fig. 24, be two activity factors in an interacting system. Let the known distance between them be d . Let the intensity I_d of this specific interaction for the known distance d be dependent upon the distance between the two activity factors in such a manner that the intensity of interaction I_s for any variable distance s between the activity factors A and B varies inversely with the distance s between them.

Then I_s will vary as $\frac{1}{s}$ if there be no other change in the other factors of the system. Consequently, for a known distance d ,

$$I_d = k \left(\frac{1}{d} \right),$$

where k is a constant which can be experimentally determined

Furthermore, since $k = I_d(d)$, it follows that if the constant k can be determined for unit factors, we can determine the intensity I_s by investigating the expression $\frac{1}{s}$. It is evident, therefore, that

$$I_s = k \left(\frac{1}{s} \right).$$

If we, for purposes of analysis, make $k=1$ in the above expression, we obtain

$$I_s = \frac{1}{s}.$$

This equation may be written $y = \frac{1}{x}$ if we regard the intensities as ordinates parallel to the Y axis and the distances s as abscissas parallel to the X axis in Fig. 25. It is evident that this is the expression for an hyperbola. The area between the vertical ordinates $x=a$ and $x=1$ and the hyperbola $y=\frac{1}{x}$ is

given by

$$\int_{\frac{1}{x}}^{\frac{x-1}{x}} \frac{1}{x} dx = \log_e x \Big|_{\frac{1}{x}}^{x-1} = \log_e(1) - \log_e(a) = 0.0 - \log_e a.$$

As a approaches 0, the limit of $\log_e(a)$ approaches infinity. In other words, a definite finite value for the required area does not exist; that is,

$$\int_{-\infty}^0 \frac{1}{x} dx = -\infty$$

Consequently the area between $x = 1$ and $x = a$, where a is not $= 0$, is given by the expression:

$-\log_2 A$

(the constant of integration has been omitted throughout the above). Similarly, the area between $x = 1$ and $x = b$ is given by:

$$\int_{x=1.0}^{x=b} \frac{1}{x} dx = 0 + \log_e(b)$$

The work W done in the displacement of B in the interacting system of Fig. 24 is given by

$W = \int I \cdot ds$. Substituting in this expression the value for

$I_s = K \left(\frac{1}{s} \right)$ and integrating, we obtain

$$W = \int k \left(\frac{1}{s} \right) ds = k \cdot \log_e s \quad \dots \dots \dots \quad (8).$$

Therefore the work done in the displacement of the activity factor B from a position $s = 1$ to a position $s = 2$ is

$$W \left[\int_{s=1}^{s=2} k \left(\frac{1}{s} \right) ds = k \cdot \log_e s \right]_1^2$$

that is,

$$W = k \left\{ \log_e 2 - \log_e 1 \right\} = k \cdot \log_e \left\{ \frac{2}{1} \right\} = a \text{ constant} \dots \dots \dots (9).$$

It follows that every system existing in dynamic equilibrium involves a constant work factor. Consequently, for

any given system, $W = F(s) = (Ma)s = \text{a constant..}$ (11)
 In Equation 11, F , is the force exhibited; M is the mass; a is the acceleration, and s is the distance. Every activity system strives continuously for a realization of this condition.

129. The Change Point.

If we plot these constants from some suitable point as a center, preferably the point which causes $\log_e s$ to equal zero, we obtain a series of concentric semi-circular lines each of which pertains to a particular constant. The point 1, for which $\log_e s_1 = 0$, divides the system into positive and negative work zones within which dynamic and static equilibrium is established. To this particular point (point 1) we have given the name *change point*. The circular lines, each defined by a specific constant, may be termed *loci of equal potentials*. In Fig. 26 we show the logarithmic curve plotted with values of $\log_e s$ as ordinates for corresponding values of s as abscissas. Fig. 27 also shows a typical Space-Time Potential zone system. The data for Figures 26 and 27 are found in Table 1.

The element of time has not, up to this point, entered into our consideration. If the motor activity factors in the system remain unchanged, we must assume that the magnitude of the work effect for one unit of time must be the same as for every succeeding unit of time.

If a system is to continue to exist in the state of dynamic equilibrium, the sum of the positive and negative work done must be equal to zero. A system rotating about the change point 1 would, moreover, continue to rotate unless disturbed by new influence factors. Furthermore, the path of motion would be along loci of equal potential. The positive work done about the center of rotation (the change point 1) would for every interval of time be equal to the negative work done. Each succeeding unit of time must develop equal amounts of work.

130. Rotary Systems.

In a simple rotary system, Fig. 28, consisting of the two bodies M and m rotating in dynamic equilibrium about the

change point 1, the positive work done in a unit of time by m in passing from the position m_0 to m_1 must be equal to the negative work done in a unit of time by M in passing from M_0 to M_1 . Furthermore, the positive work done from m_0 to m_1 must be equal to the positive work in a unit of time from m_1 to m_2 . Similarly, work M_0 to M_1 = work M_1 to M_2 , if the time element is the same.

If the bodies M and m are assumed as constants in the system, then their orbits will continue to be concentric circles unless a third activity factor be introduced into the system. If M and m remain constant and a change from the circular orbits is observed, then the cause for this change cannot be found *within* the simple system $M - m$. Moreover, a *central force* does not exist in the universe. Conditions of dynamic equilibrium exist, but no single factor in the system can be regarded as a central force. The time-honored notion that the sun, a *central force*, is located at one focus of an ellipse with the earth in the elliptic locus is nothing but a convenient mathematical myth. The point 1 may be found within the limits of the volume M , but it is not coincident with the center of mass of M . If the two points are practically coincident the continuous neutralization of the distance involved between them must be ascribed to other activity factors not depicted in the simple system shown in Fig. 28. If we grant that the sun's center of mass is located at point 1, that fact alone would not account for the deflection of the earth's path from a circular to an elliptic orbit. A cyclical change in the mass of either M or m (or both) would constitute a sufficient cause for a change in the orbits from the circular to the elliptical. However, we are not assuming that such a rhythmical mass change occurs, consequently the elliptical orbit must be due to influences not contained in the arbitrary and simple system $M - m$.

The sum total S of all the activity factors in the interacting system known as the universe may be represented by the expression, $S = R + r$, where r is the system $M - m$, and R is all the remaining factors. It is not necessary to assume that all of R is directly involved in interaction with the system r ; but in order to simplify the problem we may think of the unequilibrated portion U of R which requires

the system r for its equilibrant. It is to the system U , then, that we must ascribe any actual modifications from the circular orbits which may be observed in the system r . We shall assume that the system r will endeavor to maintain its own fundamental nature while under the interacting influence of U . We believe that such an assumption is more rational than the converse, and has the advantage of being in line with the reasonable ideas of conservation. In dynamics the path of a particle is of secondary importance since an infinite number of component paths may produce the same resultant. Consequently we feel that we are justified in supposing that the basic element of the system is the element of work done, which we have shown is a constant for a unit of time. If the converse of this is assumed, it would follow that in the equilibrated system r work is created in time without a change in U or R . The latter position would be difficult, indeed, to substantiate.

For these reasons we look for deflections and velocity changes in the orbit, but we maintain that the system r will continue to exhibit its basic characteristic, which is the development of equal work areas in equal times. If the previously developed equation of an ellipse is considered, it will be seen that this conic section satisfies the condition that the developed work areas shall be equal for equal intervals of time. This condition is shown in Fig. 29, where the path of m is deflected from the circular path by the influence U on the orbit $m_0m_1m_2$ consistent with the condition that the area described by the radius vector shall be constant for a unit of time. Thus area $(1m_0m_1) = (\text{area } 1m_1m_2)$, etc.

The Newtonian justification of Kepler's equal time-area law was based upon the assumption of a central force acting from the focus of the conic section with an intensity which depended upon the product of the masses and inversely upon the square of the distance between them. Finding no rational or empirical justification for the Newtonian formula and failing to agree with him in regard to the efficacy of a single unchanging central force to deflect a body into an elliptic orbit, we have made radically different assumptions which lead to the same final results as far as observed phenomena are concerned.

131. Electron Theory According to the Space-Time Potential.

We shall now show that the Space-Time Potential is applicable to atomic and electronic conditions. In order to test the applicability of the system outlined above, let us attempt the calculation of the so-called electrical charge on the electron.

We have already seen that, in our system of Space-Time Potential, every case of interaction involves a work constant. We have expressed this fact mathematically by the relation

$$W = (Ma) s = \text{a constant.}$$

Moreover, every activity system will so conduct itself in its various factor activities that the realization of this work constant becomes an accomplished fact unless extraneous factors intervene, in which event the law still holds, provided that the additional factor be included in the system.

Gas expansion relations come under the Space-Time Potential. If the temperature remains constant during expansion we know that $p v = \text{a constant}$, where p is the pressure exerted and v is the volume of the gas. The phenomena of thermodynamics are explainable according to the Space-Time Potential. The increase in internal energy developed when a system passes from the state 1 to the state 2 can be calculated from the Space-Time Potential. The work done in compression is merely the reverse problem of the case of expansion. In this respect, also, our Space-Time Potential is more far-reaching than Newton's formula.

132. Calculation of the Charge Exhibited by an Electron, Using the Primary or Hyperbolic Relations of the Space-Time Potential.

If our Space-Time Potential is to pass still further beyond the Newtonian limitations, we must show its applicability to electrical phenomena. Let us attempt the calculation of the electrical charge on an electron by using our fundamental relation

$$W = (Ma)s = C, \text{ a constant}$$

In order to simplify the analysis, we shall write the expression in the form

$$MR = C, \text{ where } R = a.s$$

An operative electrical work system involves a pressure constant. The liberation constant of an electron must consequently involve a decomposition constant D , consequently, $R = Dr$, where D is the decomposition voltage and r is the intensity of the current during the time t . Substituting this value for R in the expression $MR = C$, we obtain,

$$M(Dr) = C \text{ or } Mr = \frac{C}{D} = h, \dots \dots \dots \quad (12)$$

since D is a constant for any given system. If the intensity of the current r is given in amperes and the time t is expressed in hours, then our compound unit is the ampere-hour. We must also relate the intensity of the current to its dissociative effect in the electrolytic cell, since this is the very means employed in measuring current intensities. The value r , then, for any particular chemical element, becomes the number of ampere hours necessary to liberate a unit mass, the gram, per unit of chemical valence. Moreover, since the liberated masses must be in the same ratio as the atomic masses of the chemical elements considered, it follows that M may be expressed in terms of the atomic masses.

The expression $Mr = h$ may be written

$$M = h \left(\frac{1}{r} \right) \dots \dots \dots \quad (13)$$

In Table II we give the values of M and r for a sufficient number of chemical elements to plot the curve shown in Fig. 30, where M is plotted as ordinates for the corresponding values of r as abscissas. The curve in Fig. 30, is an hyperbola of identically the same order as the one shown in Fig. 25, derived for the Space-Time Potential. Here we have arrived at magnitudes of atomic and electronic proportions, and we still find the function $f=k\left(\frac{1}{s}\right)$ operative, while the Newtonian function $f=k\left(\frac{1}{s^2}\right)$ fails us completely.

By the use of our own function we can derive the value of the charge shown by an electron. In order to accomplish this we shall adopt the well-established value of 1.662×10^{-24} gram as the mass H of the hydrogen atom.¹ The remarkable researches of Kaufmann have shown that

¹ Robert A. Millikan, The Electron (1917), p. 238.

the mass of the electron is not a fixed quantity, but that it varies with the velocity, increasing as the velocity increases. This is in complete accord with the laws of the Space-Time Potential, as will be seen by inspecting Table I and Fig. 27. Moreover, the Space-Time Potential offers, for the first time, an explanation of the very phenomenon brought to light by the researches of Kaufmann. Since this variation of mass with velocity is known to be a fact, and since the values for the mass are practically constant up to a velocity of $\frac{1}{10}$ that of light (3.0×10^{10} centimeters per second in air), we shall use in our analysis that value of m for the electron which corresponds to a velocity $v = 3.0 \times 10^9 = 0.1$ (3.0×10^{10}), the velocity of light in air.

For this velocity the mass m of the electron is about $\frac{1}{1845}$ of the mass of the hydrogen atom,¹ hence

$$m = \frac{1.662 \times 10^{-24}}{1845} = 9.0081 \times 10^{-28} \text{ gram.} \quad (14).$$

If D , the liberation potential difference for the electron, and e , the charge, are known, then m may also be calculated from the expression

$$m = \frac{2eD}{v^2} \quad (15).$$

By using the well-known relations pertaining to electrochemical equivalence we have calculated the quantities set forth in Tables II, III, and IV. The relation of these values to the curve of constant areas, which is of the utmost significance to the development of the Space-Time Potential, is evident from an inspection of Fig. 30. We shall now develop the value of the charge e carried by an electron from the Faraday relations and by the use of the data contained in the tables referred to above.

Faraday's first law states that

$$uC = \frac{m}{t} \quad (16).$$

where u = a constant depending only upon the kind of the substance,

C = the current passing through the electrolyte,

m = the amount of the liberated mass, and

t = the time of duration of the current C .

¹ Robert A. Millikan, The Electron (1917), p. 184.

The value u is called the *electrochemical equivalent*, and in Table II the values of u are given for the different elements, with m in grams, t in seconds, and C in amperes.

Since 1 ampere-hour = 3600 coulombs, where 1 coulomb = 1 ampere in 1 second, it follows that $u = \frac{1}{3600R}$ gram, where R is in ampere-hours per gram per unit valence. This is evident because $3600R$ coulombs are required to liberate 1 gram of the given substance. The function $\frac{1}{R}$ therefore becomes the fundamental relation from which our analysis begins. That this function is our original Space-Time Potential function associated with proper constants is evident when we consider the motion of the liberated ion in the electrolyte as being a case of genuine motion in a work system which must operate in accordance with the fundamental laws of the Space-Time Potential.

The values u and M are related by the expression

that is, $u = kM$ = grams per coulomb; hence, if we use $\frac{1}{1845}$ as the atomic mass of the electron, we have

$u = 0.00001044 \times \frac{1}{1845}$ grams per coulomb for the electron.

If u' is the grams liberated by 1 electrostatic unit (C.G.S.),

$$u' = \frac{u}{3 \times 10^9} \text{ because } 1 \text{ coulomb} = 3 \times 10^9 \text{ C.G.S.}$$

electrostatic units, and the valence $v=1$ (18).
 Therefore,

$$u' = \frac{u}{3 \times 10^9} = \frac{0.00001044}{1845 \times 3 \times 10^9} = 1.8861 \times 10^{-18} \text{ gram.}$$

If N = number of electrons liberated by 1 C.G.S. electrostatic unit,
 m = the actual mass of the electron in grams = 9.0081×10^{-28} gram, we have

$$N = \frac{u'}{m} = \text{number of electrons liberated by 1 C.G.S. electrostatic unit.} \dots \dots \dots \quad (19)$$

$$N = \frac{1.8861 \times 10^{-18}}{9.0081 \times 10^{-28}} = 2,093,800,000 = 2.0938 \times 10^{+9} \text{ electrons.}$$

If e is the electric charge on each of the N electrons, it follows that

$N_e = 1$ C.G.S. electrostatic unit (20),

because one such unit of electricity is required to liberate the N electrons.

Therefore,

$$e = \frac{1}{N} = \frac{1}{2.0938 \times 10^{+9}} = 4.775 \times 10^{-10} \text{ C.G.S.}$$

electrostatic unit.....(21).

Let us attack the problem from another viewpoint, which will introduce new and interesting constants.

By referring to Table III, we see that $u' = k'M$ and therefore

$$k' = \frac{u'}{M} = \frac{1.8861 \times 10^{-18}}{\frac{1}{1845}} = 3.48 \times 10^{-15} \dots \dots \dots \quad (22)$$

The value k' is a constant and could have been derived from any of the given elements by taking the corresponding values of u' and M .

If M is the atomic mass and m is the actual value in grams of a given element, then the constant ratio is given by

$$l = \frac{M}{m} = \frac{\frac{1}{1845}}{9.0081 \times 10^{-28}} = 6.0168 \times 10^{23}, \text{ Avogadro's number}$$

Constant ($H = 1.0$) (23).

Now, since $N = \frac{u'}{m}$ and $u' = k'M$ (24).

by substitution we obtain

$$N = k'l = 3.480 \times 10^{-15} \times 6.0168 \times 10^{23} = 2.0938 \times 10^9 \dots \quad (26).$$

per each C.G.S electrostatic unit. Since k' and l' are both constants, it follows that N is a constant.

Since $N_e = 1$ and $N = k'l$, it follows that

$$e = \frac{1}{k_e} = 4.775 \times 10^{-10} \text{ C.G.S. electrostatic units.} \dots \dots \dots (27)$$

As before, we reason that e must be a constant since both k' and l are constants.

These facts can therefore be expressed as general laws:

1. The number of ions, whether gaseous or liquid, liberated by a given quantity of electricity is a constant independent of the kind and mass of the ion.
 2. The charge carried by a free ion, whether gaseous

or liquid, is a constant quantity independent of the kind and mass of the ion.

The following values of e , derived experimentally, show that our own value derived from the application of our Space-Time Potential is concordant with experimental facts:

- H. A. Wilson..... $e = 3.1 \times 10^{-10}$ C.G.S. electrostatic unit
- J. J. Thomson..... $e = 3.4 \times 10^{-10}$ C.G.S. electrostatic unit
- E. Rutherford..... $e = 4.65 \times 10^{-10}$ C.G.S. electrostatic unit
- R. A. Millikan..... $e = 4.774 \pm 0.005 \times 10^{-10}$ C. G. S. electrostatic unit

The discrepancies in the above experimental value of e are due to the differences in the experimental methods employed, and also to the variations in the analytical assumptions. The Millikan value of e is probably correct within the limits given.¹

The data given in Table III can be used to calculate the masses of the various ions. Knowing R , the C.G.S. electrostatic units per unit of valence necessary to liberate one gram of an ion, the mass m of an ion may be found from the relations given in Tables III and IV:

$$r' = \frac{(1.08 \times 10^{18})R}{v}; m = \frac{e}{r'}$$

In the above relation it is assumed that e is a constant representing the charge associated with the mass m of a given ion at the moment of liberation.

The fundamental electrical relations involved in Tables II, III, and IV are shown as a hyperbolic curve in Fig. 30. This curve is of the same order as the curve depicted in Fig. 25, which constitutes the primary or fundamental curve of the Space-Time Potential. The secondary work curves, similar to Fig. 26, may readily be derived from the corresponding primary hyperbolae. It is therefore evident that we have dealt, in the above analysis, with relations which inhere in the fundamental function of the Space-Time Potential. Since $mr' = e$, a constant, it follows that the electrical relations are of the same order as the volume-pressure relation which pertains to gases. In other words, the masses of

¹ Robert A. Millikan, *The Electron* (1917), p. 119.

the ions are related to the electrical charges in the same manner as the volume of a gas is related to the applied pressures.

We shall now calculate the charge carried by an electron from the secondary relations which inhere in the Space-Time Potential. By secondary relations we mean those relations which may be evolved from the analysis of the work curve.

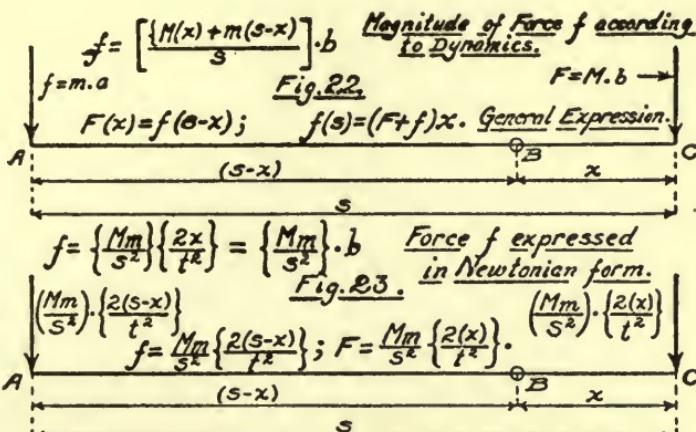
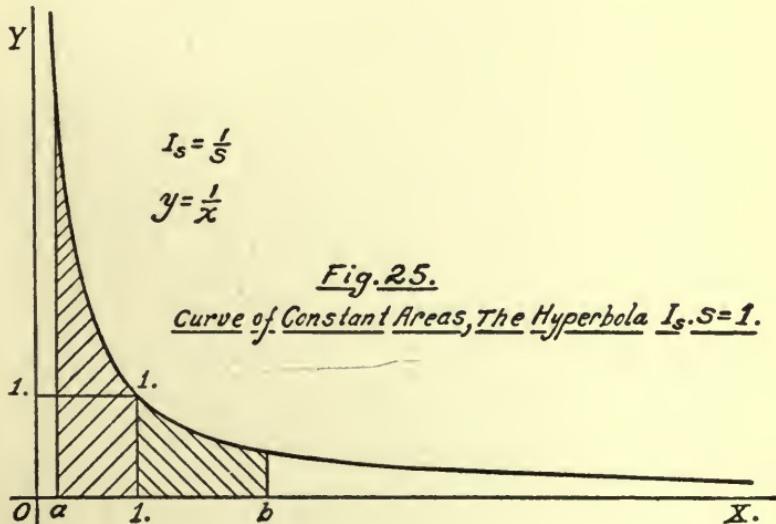
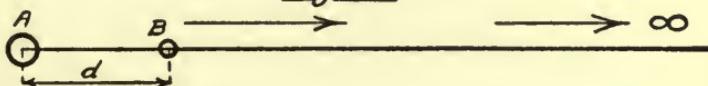
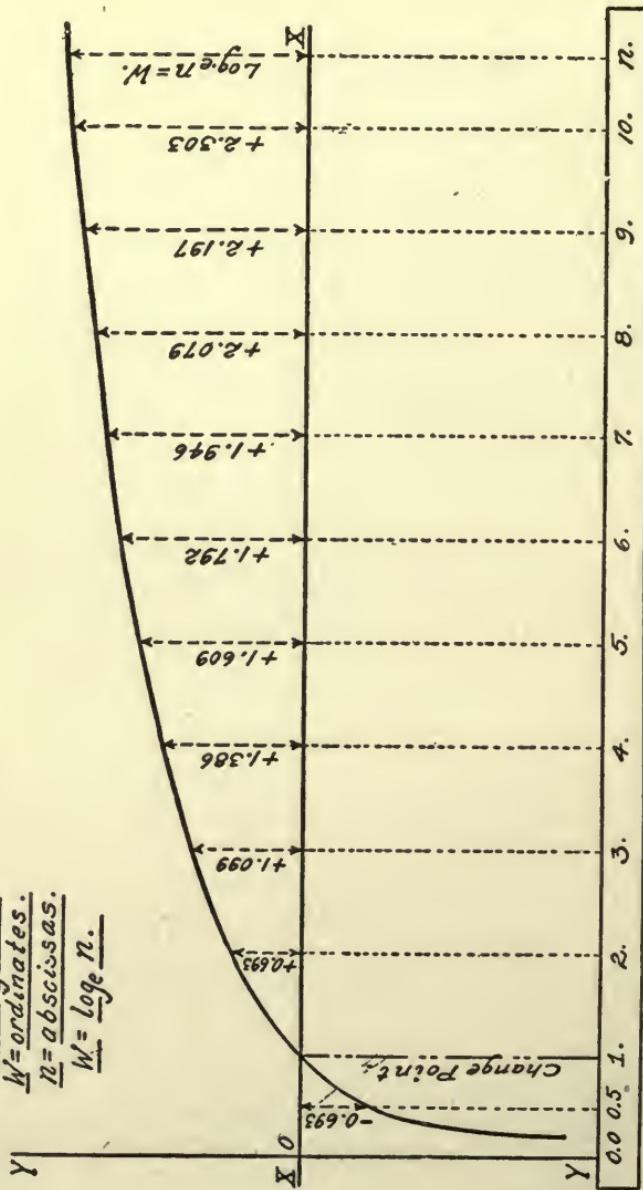
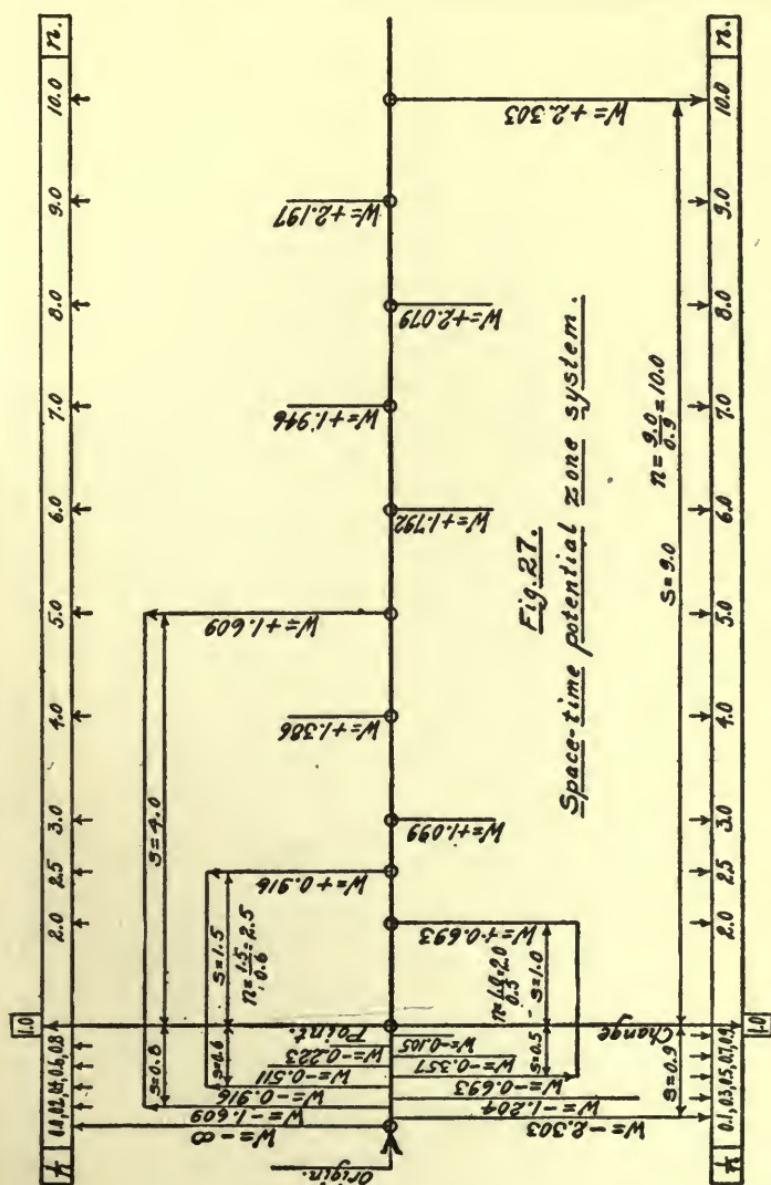
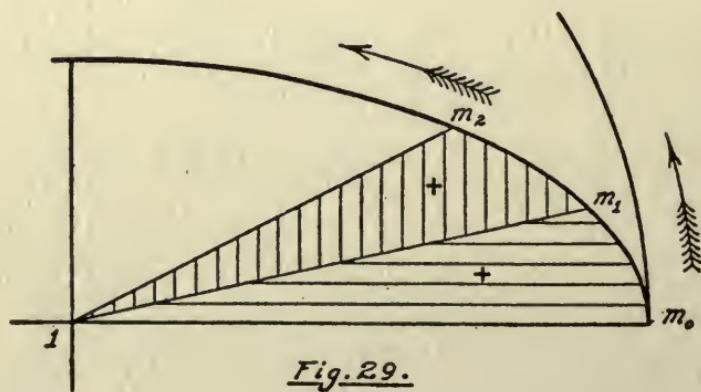
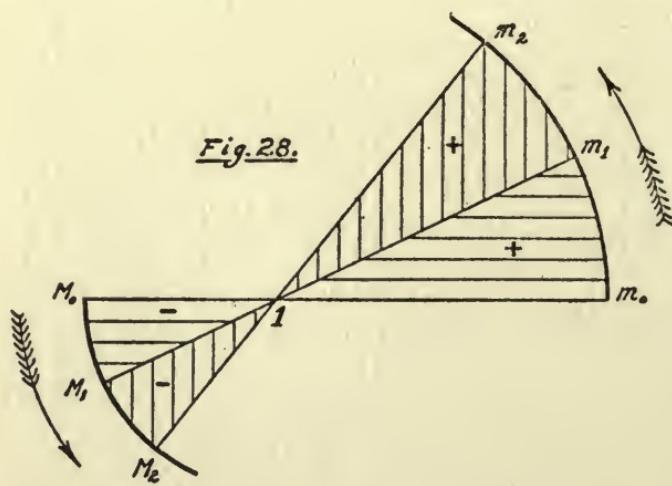
Fig. 24.

Fig. 26.
Curve of Work.
 W = ordinates
 $W = \log_e n.$







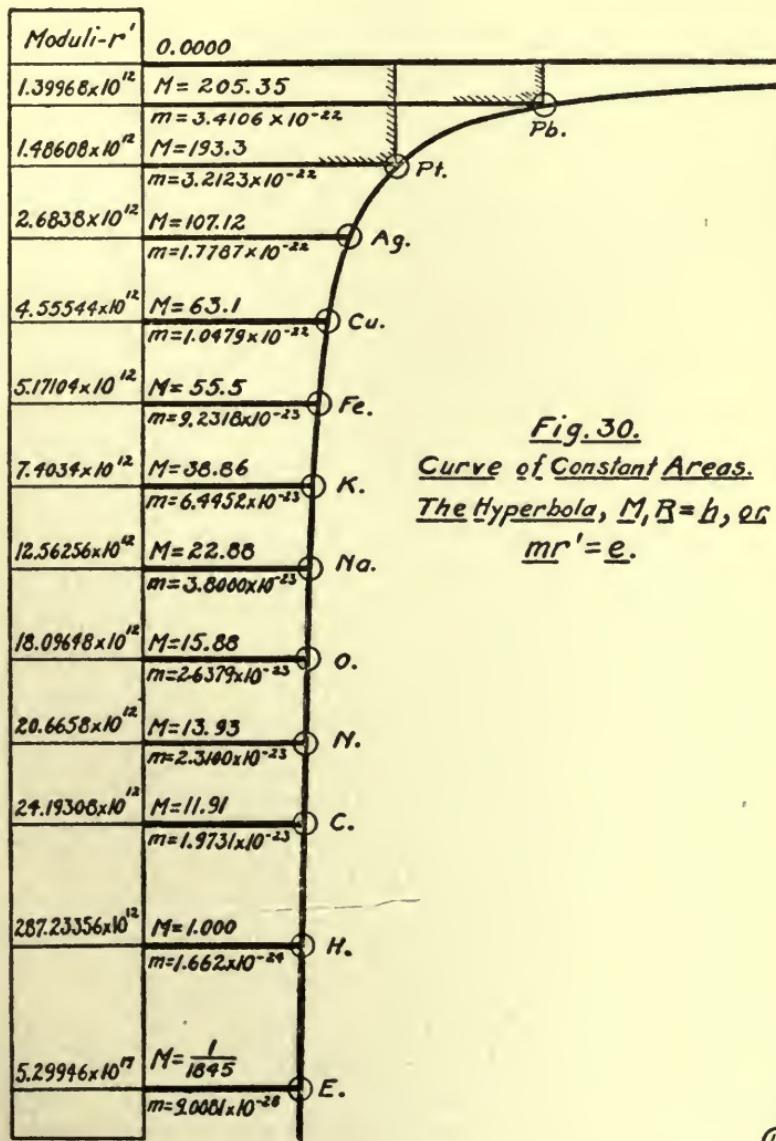


Fig. 30.
Curve of Constant Areas.
The Hyperbola, $M_r' = e$, or
 $mr' = e$.

TABLE-I.

Col. 1.	Col. 2.	Col. 3.	Col. 4.	Col. 5.	Col. 6.	Col. 7.
Location Point. <u>n</u>	Distance to Change Point. <u>S</u>	Work Done. $W_1^n = \log_e \left(\frac{n}{1} \right)$	Work Done. $W_1^n = \log_e \left(\frac{n}{n-1} \right)$	Col. 3 ÷ Col. 2 Force $M_2 = \frac{W_1^n}{S}$	$\frac{n}{n-1}$ Ratio. Distance, Velocity, Acceleration, Force.	M_n , $M_{\frac{1}{n}}$, $M = n^2 (m_n)$
	0.00	1.00	-∞	∞		
* 0.0000561492	0.9999438506	-9.7875	9.78805			377,185,000(m _n)
+ 0.00020596	0.99979404	-8.4878	8.48955			23,572,929(m _n)
0.01	0.99	-4.605	4.65			10,000m _{1.00}
0.05	0.95	-2.996	3.15			400m _{2.00}
0.10	0.90	-2.303	2.56			100m _{3.00}
0.20	0.80	-1.609	2.01			25m _{4.00}
0.30	0.70	-1.204	1.72			11.09m _{5.33}
0.40	0.60	-0.916	1.288			6.25m _{2.5}
0.50	0.50	-0.693	1.223	1.53		4.00m _{2.0}
0.60	0.40	-0.511	1.182	1.386		2.789m _{1.67}
0.70	0.30	-0.357	1.154	1.277		2.045m _{1.13}
0.80	0.20	-0.223	1.134	1.19		1.563m _{1.25}
0.90	0.10	-0.105	1.118	1.11		1.232m _{1.11}
			0.105	1.05		
Change Point.	1.00	0.00	0.000	1.00		m _{1.00}
			0.105			
1.11	0.11	+0.105	0.945	1.11		m _{1.11}
1.25	0.25	+0.223	0.892	1.25		m _{1.25}
1.43	0.43	+0.357	0.830	1.43		m _{1.43}
1.67	0.67	+0.511	0.762	1.67		m _{1.67}
2.00	1.00	+0.693	0.693	2.00		m _{2.00}
2.50	1.50	+0.916	0.610	2.50		m _{2.50}
3.00	2.00	+1.099	0.549	3.00		m _{3.00}
3.33	2.33	+1.204	0.516	3.33		m _{3.33}
4.00	3.00	+1.386	0.462	4.00		m _{4.00}
5.00	4.00	+1.609	0.402	5.00		m _{5.00}
6.00	5.00	+1.792	0.3589	6.00		m _{6.00}
7.00	6.00	+1.946	0.324	7.00		m _{7.00}
8.00	7.00	+2.079	0.297	8.00		m _{8.00}
9.00	8.00	+2.197	0.274	9.00		m _{9.00}
10.00	9.00	+2.303	0.256	10.00		m _{10.00}
20.00	19.00	+2.996	0.1575	20.00		m _{20.00}
25.00	24.00	+3.219	0.1341	25.00		m _{25.00}
50.00	49.00	+3.912	0.0798	50.00		m _{50.00}
75.00	74.00	+4.317	0.0583	75.00		m _{75.00}
100.00	99.00	+4.605	0.0465	100.00		m _{100.00}
* 4855.20	4854.20	+8.4878	0.00174854	4855.20		m +
* 17809.70	17808.70	+9.7875	0.000545591	17809.70		m *
n	n-1.	w	w ÷ (n-1).	n		m _n .
+∞	+∞	+∞	0			

TABLE-I, CONTINUED.

$\frac{1}{n}$		Origin	$W = E = \frac{mv^2}{r}$
0. 00000			$-\infty$
$\frac{f}{f}$ 0.90	The Macrocosm. Region of Unequal Radii Orbits.		-0.105
$\frac{f}{6}$ 0.9999801	$S_h = S_n$	$S_h = 1.00$	-1.98×10^{-5}
$\frac{f}{d}$ 0.99999507	$S_h = 0.00000009287$	$S_h = 0.00000493$	-4.95×10^{-6}
$\frac{f}{c}$ 0.999999990713	$S_h = 0.000000003101$	$S_h = 0.000000493$	-9.28125×10^{-9}
$\frac{f}{b}$ 0.9999999993809	$S_h = 0.0000000003101$	$S_h = 0.000000493$	-6.1875×10^{-9}
$\frac{f}{a}$ 0.9999999996899	$S_h = 0.00000000003101$	$S_h = 0.000000493$	-3.09375×10^{-9}
Change Point.			0.0000
a. 1.000000003101	$S_h = 0.00000000003101$	$S_h = 0.000000493$	$+3.09375 \times 10^{-9}$
b. 1.000000006191	$S_h = 0.00000000006191$	$S_h = 0.000000493$	$+6.1875 \times 10^{-9}$
c. 1.0000000009287	$S_h = 0.00000000009287$	$S_h = 0.000000493$	$+9.28125 \times 10^{-9}$
d. 1.00000493	$S_h = 0.000000000493$	$S_h = 0.000000493$	$+9.95 \times 10^{-6}$
e. 1.0000198	$S_h = 0.00000000198$	$S_h = 0.000000493$	$+1.98 \times 10^{-5}$
f. 1.11 $\frac{f}{2}$	The Microcosm. $n + \frac{f}{2} = 2$.	$S_h = S_n$	+0.105
<u>The Microcosm.</u>			
<u>The Macrocosm.</u>			
<u>Region of Unequal Radii Orbit.</u>			
<u>n.</u>			

TABLE II

Elements.		v.	M.	U. $U = \frac{1}{3600 R} = KM_1$ Electrochemical Equivalents per Unit Valence Grams per Coulomb.	R. Ampere = Hours per Gram per Unit Valence.	$M_1 = \frac{M}{v}$ Chemically Equivalent Atomic Masses.	h. $h = M_1 R$. Hydrogen Constant.
	Symbols.	Valences.	Atomic Masses.				
Electron	E	1	$\frac{1}{1845}$	0.00000000566095	49069.06	$\frac{1}{1845}$	26.5957
Hydrogen	H	1	1.000	0.00001044	26.5957	1.000	26.5957
Carbon	C	4	11.91	0.0000310	8.9606	2.977	26.5957
Nitrogen	N	3	13.93	0.0000484	5.7405	4.643	26.5957
Oxygen	O	2	15.88	0.0000829	3.3512	7.940	26.5957
Sodium	Na	1	22.88	0.0002388	1.1632	22.88	26.5957
Potassium	K	1	38.86	0.0004052	0.6855	38.86	26.5957
Iron	Fe	2	55.5	0.0002902	0.9576	27.75	26.5957
Copper	Cu	1	63.1	0.0006586	0.4218	63.10	29.5957
Silver	Ag	1	107.12	0.0011180	0.2485	107.12	26.5957
Platinum	Pt	2	193.3	0.0010094	0.2752	96.65	26.5957
Lead	Pb	2	205.35	0.0010718	0.2592	102.675	26.5957

Important Relations

$$U = \frac{1}{3600 R} \text{ gram. } K = \frac{U}{M_1} = 0.00001044 = U \text{ for Hydrogen} = \text{Constant}$$

$$R = \frac{h}{M_1}, \quad UR = 0.000278 = \frac{1}{3600} = \text{Constant.}$$

$$h = M_1 R = 26.5957$$

TABLE III

Atomic Mass Moduli in C.G.S. Electrostatic Units

Elements.	Valences.	M Atomic Masses.	u' Moduli	R Ampere = Hours per Gram per Unit Valence.	r' Moduli
			$u' = \frac{v U}{(3 \times 10^9)}$		$r' = \frac{(1.08 \times 10^{13}) R}{v}$
Electron	1	$\frac{1}{1845}$	1.886×10^{-18}	49069.06	5.29946×10^{17}
Hydrogen	1	1.000	3.48×10^{-15}	26.5957	287.23356×10^{13}
Carbon	4	11.91	41.33×10^{-15}	8.9606	24.19308×10^{13}
Nitrogen	3	13.93	48.40×10^{-15}	5.7405	20.6658×10^{13}
Oxygen	2	15.88	55.26×10^{-15}	3.3512	18.09648×10^{13}
Sodium	1	22.88	79.60×10^{-15}	1.1632	12.56256×10^{13}
Potassium	1	38.86	135.06×10^{-15}	0.6855	7.4034×10^{13}
Iron	2	55.5	193.46×10^{-15}	0.9576	5.17104×10^{13}
Copper	1	63.1	219.53×10^{-15}	0.4218	4.55544×10^{13}
Silver	1	107.12	372.66×10^{-15}	0.2485	2.6838×10^{13}
Platinum	2	193.3	672.93×10^{-15}	0.2752	1.48608×10^{13}
Lead	2	205.35	714.53×10^{-15}	0.2592	1.39968×10^{13}

TABLE IV

The Masses of Atoms Developed from the Charge e and the Moduli r'. Electrophysical Constants

Elements.	M. Atomic Masses.	m $m = \frac{e}{r'}$. Masses of Atoms. (Gram).	Constants.
Electron	$\frac{1}{1845}$	9.0081×10^{-28}	1—Coulomb = 3×10^9 C.G.S Electrostatic Units. 1—Ampere Hour = 3600 Coulombs. 1—Ampere Hour = 3600 $(3 \times 10^9) = 1.08 \times 10^{13}$ (C.G.S. Electrostatic Units).
Hydrogen	1.000	1.662×10^{-24}	<i>Constants.¹</i> $e, \frac{e}{m}, N', k', N,$ and $h.$ Electron Charge, $e = 4.7738$ $\times 10^{-10} = mr'$. (Electrostatic Units). $e = 1.59127 \times 10^{-20}$ (Electromagnetic Units). $\frac{e}{m} = 1.7664 \times 10^7$ (Electromagnetic Units). $= 5.2994 \times 10^{17}$ (Electrostatic Units). Avogadro's Constant, $N' = \frac{M}{m} = l.$ $N' = 6.0679 \times 10^{23}.$ $k' = \frac{u'}{M} = \frac{K}{3 \times 10^9} = 3.48 \times 10^{-15}$ $N = \text{Number of Electrons}$ $\text{Liberated by } 1 - \text{C.G.S.}$ $\text{Electrostatic Unit.}$ $N = k'l = \frac{u'}{m} = 2.0938 \times 10^9$ $h = M, R = 26.5957$
Carbon	11.91	1.9731×10^{-23}	
Nitrogen	13.93	2.3100×10^{-23}	
Oxygen	15.88	2.6379×10^{-23}	
Sodium	22.88	3.8000×10^{-23}	
Potassium	38.86	6.4452×10^{-23}	
Iron	55.5	9.2318×10^{-23}	
Copper	63.1	1.0479×10^{-22}	
Silver	107.12	1.7787×10^{-22}	
Platinum	193.3	3.2123×10^{-22}	
Lead	205.35	3.4106×10^{-22}	

¹ These constants were developed by the writer from data given in this work.

APPENDIX C

CALCULATIONS INVOLVING HYPERBOLIC LOGARITHMS

133. Fundamental Relations and Typical Computations Involving Hyperbolic Logarithms.

The reader who is familiar with mathematical analysis will find nothing new in the following discussion on hyperbolic logarithms. This appendix is intended to assist those readers who are less familiar with mathematical manipulations in deriving for themselves the hyperbolic relations which constitute the physico-mathematical foundations of the Space-Time Potential.

Logarithms calculated to the base $e = 2.7182818285+$ are known as *Napierian, natural, or hyperbolic logarithms*, in contradistinction to logarithms calculated to the base 10, which are called *common logarithms*. We will use the term hyperbolic logarithm in this discussion in preference to natural or Napierian, because the fundamental curve pertaining to our system is an hyperbola.

Let N be any given number. Then the logarithm of N to the base C is written $\log_C N$ and the logarithm of N to the base e is written $\log_e N$.

The following fundamental equations hold good:

Using any other base as e , we have

because $N = C^y$. Now since $y = \log_c N$, we have

Now, if $N = e$, and knowing that $\log_e N = 1$, Equation 31 becomes $\log_e N = \log_e N(\log_e C)$, which gives

From Equation 31 it follows that

But from Equation 32, $\frac{1}{\log_e C} = \log_e e$, and, therefore,

Now, if C be the base 10. of the common or Briggs logarithms, and e be the base 2.7182818+ of the hyperbolic system, Equation 34 becomes

Consequently, $\log_{10}N = \log_{10}e(\log_e N)$ (36),

From Equation 32 we have the following relations:

$$\log_{10}e = \frac{1}{\log_e 10} \text{ and } \log_e 10 = \frac{1}{\log_{10}e} \dots \dots \dots \quad (38),$$

Therefore Equation 37 may be given the form

$$\text{Let } M = \log_{10} e = \log_{10}(2.7182818) = 0.4342945 \dots \dots \dots \quad (40)$$

$$z = \frac{1}{M} = \frac{1}{\log_{10} e} = \log_e 10 = \frac{1}{0.4342945} = 2.3025851 \dots \dots \dots (41)$$

Then Equation 36 becomes

and Equation 37 takes the form

$$\log_e N = \frac{1}{M} (\log_{10} N) = \frac{1}{0.4342945} (\log_{10} N) \dots \dots \dots \quad (43)$$

But since $\frac{1}{M} = z = 2.3025851$, we have for Equation 43,

Equations 42, 43, and 44 constitute our transformation equations. In the above the value M is known as the *modulus of common logarithms*.

The reciprocal $\frac{1}{N}$ of any number N is of importance in the Space-Time Potential. The reciprocal $\frac{1}{N}$ is generally given as a decimal fraction.

The following relation is evident:

$$\log_e \left(\frac{1}{N} \right) = \log_e 1 - \log_e N = 0.0 - \log_e N = -\log_e N \quad \dots \dots \dots \quad (45).$$

Therefore,

$$\log_e\left(\frac{1}{N}\right) = -\log_e N = -z(\log_{10} N) = -2.3025851(\log_{10} N) \dots \quad (46)$$

In order to find the hyperbolic logarithm of a decimal fraction, place it $= \frac{1}{N}$, solve for N , and substitute the value of N thus obtained in the expression $2.3025851(\log_{10}N)$ of Equation 46.

In Table I, col. 1, we find the value 0.0000561492. In order to illustrate the procedure, we will calculate the hyperbolic logarithm of this decimal fraction.

$$\text{Let } \frac{1}{N} = 0.0000561492, \text{ then } N = \frac{1}{0.0000561492} = 17809.7$$

$$\text{From Equation 46, } \log_e\left(\frac{1}{N}\right) = -\log_e N = -\log_e(17809.7)$$

But $\log_e 17809.7 = 2.3025851(\log_{10}17809.7)$, and since $\log_{10} 17809.7 = 4.2506574$, it follows that

$\log_e 17809.7 = 2.3025851 (4.2506574)$. Performing this multiplication by common logarithms, we have

$$\log_{10}2.3025851 = 0.3622157$$

$$\log_{10}4.2506574 = 0.6284561$$

$$\log(\log_{10}17809.7) = 0.9906718$$

The number corresponding to the common logarithm 0.9906718 is 9.7875,

which therefore $= \log_e 17809.7$.

Since $\log_e\left(\frac{1}{N}\right) = -\log_e N$, it follows that

$$-9.7875 = \log_e\left(\frac{1}{N}\right) = \log_e\frac{1}{17809.7} = \log_e(0.0000561492).$$

In order that every phase of these transformations may be understood we give the following illustrative examples.

Given the hyperbolic logarithm -2.99573 , required the corresponding number.

Using Equation 42, $\log_{10}N = M(\log_e N)$, we have, since

$$-2.99573 = \log_e\left(\frac{1}{N}\right) = -\log_e N,$$

$$\log_{10}N = 0.4342945(\log_e N)$$

$= 0.4342945 (2.99573)$; performing this multiplication by common logarithms, we have

$$\log_{10}0.4342945 = 9.6377843 - 10$$

$$\log_{10}2.99573 = 0.4765030$$

$$\log(\log_{10}N) = 0.1142873$$

The number corresponding to the common logarithm 0.1142873 is $1.3010300 = \log_{10}N$. Therefore N , the reciprocal of the required number, is $= 20$.

But $-2.99573 = \log_e\left(\frac{1}{N}\right)$, therefore $\frac{1}{N} = \frac{1}{20} = 0.05$

Given the decimal fraction 0.4, we find the hyperbolic logarithm.

Let $\frac{1}{N} = 0.4$, then $N = \frac{1}{0.4} = 2.5$, as before,

$$\log_e 2.5 = 2.3025851 (\log_{10} 2.5);$$

but $\log_{10} 2.5 = 0.3979400$, consequently $\log_e 2.5 = 2.3025851$ (0.3979400), and using common logarithms for the multiplication, we have

$$\log_{10} 2.3025851 = 0.3622157$$

$$\log_{10} 0.3979400 = \underline{9.5998176 - 10}$$

$$\log(\log_e 2.5) = \underline{9.9620333 - 10}$$

The number corresponding to the common logarithm $9.9620333 - 10$ is 0.91629, which therefore $= \log_e 2.5$

Since $\log_e\left(\frac{1}{N}\right) = -\log_e N$, we have

$$-0.91629 = \log_e\left(\frac{1}{N}\right) = \log_e\left(\frac{1}{2.5}\right) = \log_e(0.4).$$

The above examples should suffice to make clear the method by which points and loci in the Space-Time Potential are calculated.

APPENDIX D

THE SECONDARY FUNCTION OF THE SPACE-TIME POTENTIAL, AND THE ELECTRICAL CHARGE e

134. Calculation of the Charge exhibited by an Electron,
Using the Secondary or Logarithmic Relations of the
Work Curve.

We shall now proceed with the direct attack of the problem before us. We shall make use, in this attack, of nothing other than the well-established laws of dynamics, and in particular that portion of dynamics which deals with uniformly accelerated motion where no initial velocity is involved. In other words, we assume that the systems which we consider are responsive parts of an all-inclusive unitary organism whose activities in all its parts are describable in terms of the Space-Time Potential.

In this and many other respects we differ from classical science, which heretofore has had no single relation capable of expressing all phenomenal activities. The Space-Time Potential provides us with this single relation, which includes gravitation, electricity, thermodynamics, dynamics, and statics as mere categories of cosmic interaction evolving in accordance with its simple and universally applicable laws.

We shall have occasion to use the following relations of dynamics pertaining to uniformly accelerated motion for no initial velocity:

$$s = \frac{vt}{2} = \frac{v^2}{2a} = \frac{at^2}{2} \quad \dots \dots \dots \quad (49).$$

$$t = \frac{v}{a} = \frac{2s}{v} = \sqrt{\frac{2s}{a}} \quad \dots \dots \dots \quad (50)$$

In the foregoing expressions:

v = the velocity,

a = the acceleration,

s = the distance, and

t = the time.

We assume that the general expression ($\frac{1}{2}mv^2$) represents correctly the energy of any material system whose mass is m and velocity v . Consequently, if we let

e = the charge (C.G.S. electrostatic units),

D = the potential difference (C.G.S. electrostatic units) of liberation,

m = the mass in grams,

v = the velocity in centimeters per second,

a = the acceleration,

E = the energy of the system,

s = the spatial displacement for the work W ,

W = the work done by or upon the system during the displacement,

N = number of electrons liberated by a current of 1-C.G.S. electrostatic unit at a difference of potential D (C.G.S. electrostatic units),

then

$$E = W = \int F \cdot ds = \frac{1}{2}mv^2 = eD \dots \dots \dots \quad (51)$$

Experimental evidence shows that the ratio $\frac{e}{m}$ is independent of the difference of potential. Consequently, for the limits within which m is practically constant the magnitude of the ultimate value of D required to liberate an electron from an atomic structure is a function of K , the number of electrons constituting the particular atom. This will be true universally if future research shall show that the charge e is always a constant relative ratio like the velocity of light. The evidence of modern research is overwhelmingly in favor of this assumption. If this be true, then the two fundamental relativity ratio constants of the physical universe are, first, the velocity of light V , and, second, the electric charge e associated with the electron. We may unify these two fundamentals into the single relation: $eV = \text{constant}$, thus relating the charge carried by an electron to the velocity of light.

The ultimate value of D , the liberation difference of

potential for the electron, may be calculated from Equation 14 if we assume the constancy of the known relativity ratio e . Any attempt to deny the correctness of this procedure involves the repudiation of the correctness of Expression 51, above. We maintain that if the expression holds for the macrocosm, it must hold for its constituent miscrocosmic groups.

From our relativity standpoint of the Space-Time Potential the electric charge e is well defined by the expression

$$e = \frac{(ma)s}{D} = \frac{E}{D} = \frac{W}{D},$$

indicating the complete relativity of the value e . As (ma) approaches an infinite value, D also approaches an infinite magnitude. From the viewpoint of the Space-Time Potential, the relativity ratio e remains a constant throughout the variation of E and D .

The fact that the experimental difference of potential D required to liberate the electron varies is due to the variations in the conditions which pertain to the experiment and in the atomic aggregates used. This experimental variation of D is equally often noted for liquid and gaseous ions, but this fact effects neither the value of the relativity ratio e nor the liberation constant D which pertains to the electronic particle.

Consequently we are justified in using Expression 51 for the calculation of the value D . In the preceding we have found that $e = 4.775 \times 10^{-10}$ C.G.S. units, and $m = 9.0081 \times 10^{-28}$ gram. This value of m corresponds to a value of $v = 3.0 \times 10^9$ centimeters per second. Transforming Equation 51 and substituting the above values, we have

$$D = \frac{0.5mv^2}{e} = \frac{0.5(9.0081 \times 10^{-28})(3.0 \times 10^9)}{4.775 \times 10^{-10}} = 8.4878$$

where $D = 8.4878$ is in the C.G.S. electrostatic system of units.

We purpose to develop the charge e by a direct use of the Space-Time Potential in order to show its applicability to the investigation of electrical phenomena. We will make use of Equation 51, substituting therein the now known values of D and m . Consequently we have

From Equations 20 and 21, we have

$$eN=1 \quad \text{and} \quad e=\frac{1}{N};$$

substituting this value of e in Equation 51, we have

$\frac{1}{N}(D) = (ma)s$, which gives

$$N = \frac{D}{(ma)s} = \frac{8.4878}{(9.0081 \times 10^{-28})as} \dots \dots \dots (53).$$

Since $D = N(ma)s$, it follows that D is that difference of potential which is required to displace N electrons showing a charge e and having a mass m through a distance s . Furthermore, the N liberated electrons complete their migration over the distance s in a unit of time, i.e., one second. This does not mean that the translation of one single electron through the distance s will require a unit of time; in fact it will be shown that t , the time of migration of one electron, is equal to 0.0000032361 second. Be it remembered that the value of m in Equation 53 refers to one electron. Before we can solve Equation 53, we must evaluate the acceleration a and the distance s . We shall employ the Space-Time Potential for this evaluation.

Let us place the value D , the difference of potential, = 8.4878, directly in the Space-Time Potential as exhibited in Table I, Appendix B. This means that we regard D = 8.4878 as an hyperbolic logarithm. If n be the number corresponding to the hyperbolic logarithm 8.4878, we have $\log_{10} n = M(\log_e n)$; and since $\log_e n = 8.4878$, we have $\log_{10} n = 0.4342945(8.4878)$

= 3.686,2068, for which logarithm

$n = 4855.2$, which value is found in Table I.

Since $s = (n - 1)$, we have

$$s = 4855.2 - 1.0 = 4854.2 \text{ centimeters.}$$

If t is the time required by one electron to migrate the distance s , we have from Equation 50,

$$t = \frac{2s}{v} = \frac{2 \times 4854.2}{3 \times 10^9} = 0.0000032361 \text{ second} \quad \dots \dots \dots (54)$$

The value $v = 3 \times 10^9$ c. is the velocity of the electron as used previously.

From Equation 48 we have

Substituting these values of a and s and using m as 9.0081×10^{-28} in Equation 53, we obtain

$$N = \frac{D}{(ma)s} = \frac{8.4878}{(9.0081 \times 10^{-28})(9.2703 \times 10^{14})(4854.2)} \dots (56).$$

$N = 2.0938 \times 10^9$, which is identical with the value of N previously obtained (see Equation 19).

Consequently it follows that since

$e = \frac{1}{N}$, $e = 4.775 \times 10^{-10}$ C.G.S. electrostatic unit, which agrees with the previously calculated value of e , as it must, by virtue of the fact that the value obtained for N by the two different methods is identical. Consequently we have shown conclusively that the Space-Time Potential is capable of deriving directly the value e .

135. Fundamental Physico-mathematical Relations of the Space-Time Potential.

The fundamental relations which inhere in the nature of the Space-Time Potential will now be considered.

Let

W_n = work done from point n to change point 1,

W_n = work done from point $\frac{1}{n}$ to change point 1,

t_n = time of translation through distance s_n ,

$t_{\#}$ = time of translation through distance $s_{\#}$,

n =number whose hyperbolic logarithm is W_n ,

Equation 60 is evidently true because $t_n = t_{\frac{1}{n}}$.

$$m_{\frac{1}{n}} = n^2(m_n); \quad m_n = \frac{m_{\frac{1}{n}}}{n^2}. \quad \dots \quad (65).$$

For values of $n < 1.11 - \frac{1}{f}$ (point f) and for values of $\frac{1}{n} > 0.90$ (point $\frac{1}{f}$), see Table I, continued.

The following facts and relations are noteworthy:

$$W_n = W_{\frac{n}{2}}; \quad t_n = t_{\frac{n}{2}}; \quad s_n = (n-1); \quad s_{\frac{n}{2}} = \frac{(n-1)}{n} \dots \text{ (57 and 58).}$$

From Equation 66 we have

$\frac{s_n}{s_1} = n' = 1$. Equations 60 to 65, inclusive, take the form:

$$v_p = v_{\frac{1}{2}}; \quad a_p = a_{\frac{1}{2}}; \quad m_p = m_{\frac{1}{2}}; \quad (m_p a_p) = (m_{\frac{1}{2}} a_{\frac{1}{2}}) \dots \dots \dots (69).$$

Since $s_n = (n-1)$, and $s_{\frac{1}{n}} = \left(1 - \frac{1}{n}\right)$; $s_n = s_{\frac{1}{n}}$,

It follows that

Equations 66 to 70, inclusive, pertain to the microcosm, with $n < 1.11$, $\frac{1}{n} > 0.90$

The above developed relations are found partially exemplified in Table I, and they serve for the calculation of the fundamental elements of the Space-Time Potential.

136. The Macrocosm and the Microcosm.

The Space-Time Potential differentiates itself into two systems having distinctive properties. The first system is obedient to the dictates expressed by Equations 57 to 65, inclusive, and the second system is submissive to the mandates of Equations 66 to 70, inclusive. In the first system s_n does not equal $s_{\#}$; in the second system s_n equals $s_{\#}$.

The first system, that of unequal radii ($s_n \neq s_{\#}$) is represented in Fig. 27 and Table I, Appendix B. The first system is the *macrocosmic system*, the great world of molecules, bodies and planets. The second system is the *microcosmic system*, the small world of "positons," "energons," electrons, and atoms. The second system is that of equal radii ($s_n = s_{\#}$) with the positive loci continuous with the corresponding negative loci. The change point bisects the vectorial distance between positive and negative loci of equal magnitude in the microcosm. This the change point does not do in the macrocosm. Some phases of the microcosm are shown in Table I, Continued, Appendix B. A rotary system corresponding to $n = x$ and $\frac{1}{n} = \frac{1}{x}$ in Table I, Continued, is in dynamic equilibrium and constitutes an elementary type of activity structure. We give to this elementary type of microcosmic structure the name "energon." From the standpoint of the Space-Time Potential, the *energon* is a unit composed of positive and negative work factors of equal magnitude, eternally inseparable in the world of phenomenal interaction. Those mysterious antipodal activities, known as attraction and repulsion, no longer remain enigmatical and unintelligible. Gravitational attractions and electrical repulsions are but phases of interaction in the Space-Time Potential. The positive work factors of the *energon* is the basis of the so-called positive nucleus of the modern electronic theory. It no longer remains the elusive mystery of the electronic hypothesis, but becomes the well-defined complement in a structure typical of all microcosmic and macrososmic structures.

APPENDIX E

ELECTROLYTIC IONIZATION—THE KAUFMANN EFFECT—THE RELATION OF WORK LOCI TO THE ATOMIC STRUCTURE AND DIAMETER—AVOGADRO'S CONSTANT—THE SPACE-TIME POTENTIAL THEORY OF LIGHT SUBSTANTIATED BY RECENT ASTRONOMICAL OBSERVATIONS

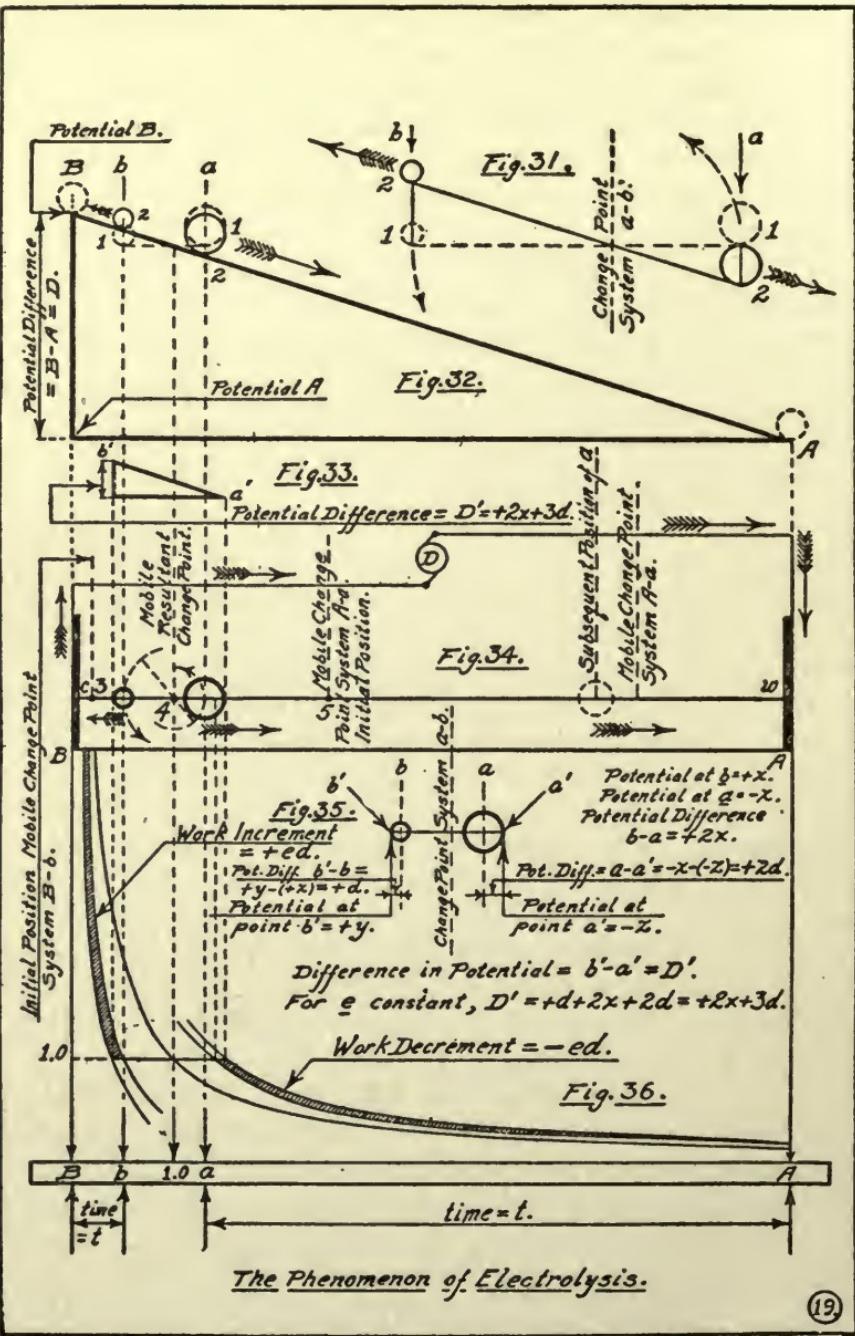
137. Electrolytic Ionization According to the Space-Time Potential.

The Space-Time Potential enables us to comprehend the action in an electrolytic cell. Consider the rotary molecular system *a-b* of Fig. 31, existing in dynamic equilibrium. Let the solute system *a-b* be immersed in the solvent component *c-d* of the electrolytic cell *A-B*, *a-b*, *c-d*, shown in Fig. 34. The displacements of the solvent molecules of the system *c-d* by the solute molecules *a-b* results in a readjustment of work loci in a manner tending toward the restoration of equilibrium in the combined system *A-B*, *a-b*, *c-d*. Being a different molecular structure, the solvent system *c-d* differs in the configuration of its work loci from the solute system *a-b*, consequently the unbalanced potential differences initiated at immersion strive at once for a readjustment tending toward equilibrium.

The modified system *a-b* plus the modified system *c-d* constitutes the electrolyte of the cell shown in Fig. 34. Let us now subject the combined system to an increasing difference of potential. The modified system *a-b* is considered as existing in a state of rotation about its change point at the time when a potential difference is impressed upon the cell system. The increasing potential difference exerts a damping influence upon the rotary system *a-b*. The angular velocity decreases with an increase in the potential difference until it becomes equal to zero at the time when the decomposition voltage (*B-A*) = *D* has been reached. Simultaneously with this damping effect, the system *a-b* is displaced so that

its *change point* becomes coincident with the *mobile resultant change point* of the entire cell system. At the time when angular accelerations have become equal to zero, then linear accelerations are given to the systems *a* and *b* along the *work line c w*. Since the potential at *w* is not equal to the potential at *c*, it follows that the mobile factors in the cell must move continuously while a difference of potential between *A* and *B* is maintained. The mobile portions of the cell system strive to neutralize the potential difference between *A* and *B*. As the resultant change point 4 moves toward *B*, the change point 3 of the system *b-B* precedes it and should arrive at *B* in advance of point 4. The system *b* must increase, for the distance *C-3* approaches zero more rapidly than the distance *b-3*, which also tends toward zero. Simultaneously with the beginning of an increase in the system *b*, we must have a decrease in the system *a* accompanied by a retrograde motion of *a*. Fig. 36 shows the work relations which obtain to the system. The increment of work $+ed$ is equal to the decrement of work $-ed$. Observations in which these positive and negative work factors are clearly manifest are responsible for the creation of that interdependent action phase entity which is known as the charge. The fact is that the charge, regarded as a separate independent entity, does not exist. Work increments and decrements are the given data of experience; charges are conceptual conveniences resorted to in physico-mathematics. The work increment $+ed$ appears at the electrode *c*, and simultaneously the work decrement $-ed$ is found at the electrode *w*. The algebraic sum of the work done within the cell is zero.

The Hittorf experiments no longer remain subject to the guesses of an "extraordinary hypothesis," but follow as consequences from the Space-Time Potential. In fact, none of the herinbefore enumerated objections to the ionic hypothesis remain as such for the relations pertaining to the Space-Time Potential,



The scope of the present discussion makes it impossible to give further consideration to this phase of the subject, which, we realize, has been merely touched upon *en passant*, without in any way doing it justice. That part of our discussion which pertains to the phenomenon of electrolysis must therefore be regarded as suggestive rather than replete with detail.

138. The Kaufmann Effect.

When a mass-acceleration kern or center passes successive work loci, the kern must obey the mandates of each consecutive locus and assume the mass-acceleration magnitude which pertains to the particular locus at which it may be found during its migration.

If the space s traversed in a unit of time be related to the distance K , the Kosmometer = 3×10^{10} centimeters; then we have from the fundamental relations of the Space-Time Potential:

$$\frac{1}{n} = \left(1 - \frac{s}{K}\right) = \left(1 - \frac{v}{V}\right)$$

and

$$W_{\frac{1}{n}} = \log_e \left(\frac{1}{n} \right) = \log_e \left(1 - \frac{v}{V} \right); \quad \left(m_{\frac{1}{n}} a_{\frac{1}{n}} \right) = \frac{W_{\frac{1}{n}}}{s_{\frac{1}{n}}} = \frac{\log_e \left(1 - \frac{v}{V} \right)}{\frac{v}{V}}$$

This expression, evolved from our system of relative physical interaction and interdependence, describes mathematically the variation of the kern magnitude with the variation in velocity.

In Table V the values derived from the expression of Lorentz-Einstein and the writer are compared with the observed values of Kaufmann.

TABLE V

$\frac{v}{V}$	Lorentz-Einstein. $\left\{1 - \left(\frac{v}{V}\right)^2\right\}^{-\frac{1}{2}}$	ReuterdaHL. $\frac{\log_e \left\{1 - \frac{v}{V}\right\}}{\frac{v}{V}}$	Kaufmann. (Observed).
0.75	1.512	1.8391	1.65
0.78	1.598	1.9315	1.83
0.80	1.667	2.000	1.88
0.83	1.793	2.1242	2.09
0.86	1.960	2.2748	2.43
0.88	2.105	2.3974	2.73
0.90	2.294	2.5472	3.09

139. The Relation of Work Loci to the Atomic Structure and Diameter.

From Table I, Continued (Appendix B), we may derive our basic ideas concerning the structure of the atom. The work loci shown in this table constitute the orbits for the sub-atomic particles. We have previously stated that the sub-atomic particles are capable of variation in an ascending and a descending manner from a neutral state—the energon. The orbits in the case of atoms are circular concentric work loci. The radial distances of the orbits are functions which depend upon the system and the fundamental relations of the Space-Time Potential for their magnitude. If work is done upon or by the system, the components thereof undergo corresponding changes. The work loci configurations are modified to conform with the involved work factor. When an energon is caused to migrate from one work locus or orbit to another, it assumes that magnitude which conforms with the work constant of the orbit upon which it becomes located. An energon located upon the outermost orbit of the atom is an electron. Passing inward toward the center, we find energons in various loci phases until we reach the limit of variation in

the positon. We find, in fact, variations in the energonic condition which not only suggest the spectrum, but make it possible. Millikan makes the following statement concerning the justly famous Bohr atom: "Its chief difficulty arises from the apparent contradiction involved in a non-radiating electronic orbit—a contradiction which would disappear, however, if the negative electron itself, when inside the atom, were a ring of some sort capable of expanding to various radii, and capable, only when freed from the atom, of assuming essentially the properties of a point charge, such as we find it endowed with in experiments upon cathode rays, β -rays, and ionization in gases."¹

Millikan keenly realizes that a fixed primordial particle is incapable of explaining the phenomena in question. In this work we have repeatedly pointed out the necessity of variability in the primordial particle in conformity with the requirements of our universal relativity system. It is evident that the atom of the Space-Time Potential obviates entirely the difficulties encountered in the Bohr atom. It is also clear that the diameter of an atom cannot be regarded as an absolutely fixed quantum. Whenever we speak of the diameter of an atom, therefore, we must define the conditions imposed upon the system. By defining a normal condition we would be in a position to evaluate the corresponding diaméter, which then would constitute the normal value.

140. Avogadro's Constant.

Table IV, Appendix B, affords the required data for the computation of Avogadro's Constant. The following relations are involved in the calculation:

R = ampere-hours per gram per unit valence,

$$r' = \frac{(1.08 \times 10^{13}) R}{v}, \text{ C.G.S. electrostatic units,}$$

$m = \frac{e}{r'} =$ actual mass of atom in grams,

M = atomic mass of atom (ratios with hydrogen = 1.0)

$$N' = l = \frac{M}{m}$$

¹ Robert A. Millikan, *The Electron*, p. 216.

The results of the calculations are given in Table VI.

TABLE VI
Avogardo's Constant

Elements.	$N' = \frac{M}{m}$
Hydrogen	6.01685×10^{23}
Carbon	6.03596×10^{23}
Nitrogen	6.03027×10^{23}
Oxygen	6.01975×10^{23}
Sodium	6.02100×10^{23}
Potassium	6.02931×10^{23}
Iron	6.01180×10^{23}
Copper	6.02134×10^{23}
Silver	6.02219×10^{23}
Platinum	6.01800×10^{23}
Lead	6.02084×10^{23}
 Average value of N' 6.022482×10^{23}	
For Hydrogen $M = 1.000$	

Transforming this average value of N' based upon Hydrogen $M = 1.000$ to the Oxygen Standard $M = 16$, we have
 $N' = \frac{16.00}{15.88} (6.022482 \times 10^{23}) = 6.0679 \times 10^{23}$.

141. The Space-Time Potential Theory of Light Substantiated by Recent Astronomical Observations.

At the time when the fundamental concepts of the Space-Time Potential were developed, the writer was confident that future investigations in the field of physical astronomy would bring forth facts substantiating that portion of his work which dealt with the phenomenon of light

as a particular case of universal interaction between material particles. The reader is referred to paragraph 76 (Fields of Interaction) and paragraph 86 (Primary and Secondary Matter in the Rôle of Concurrent and Excitant Systems). From these paragraphs and many other similar statements in the text it is evident that we regard light as a case of interaction between material particles. The path of an excitant particle in an interacting field like the sun's is then determined by the conditions set forth in paragraph 76. The path of propagation of an excitant light particle must sustain deviation whenever the particle passes a body like the sun. The observations made of the total solar eclipse (May, 1919) prove conclusively that the path of propagation of light emanating from a star is deviated from its previously assumed rectilinear path when it passes near the sun.

This astounding discovery proves:

1. That light is a material and not an etherial phenomenon.
2. That the ether medium is not a physical reality, but merely a mathematical myth.
3. That the laws of the primordial particle (microcosm) are the laws of the universe (macrocosm).
4. That interdependence is universal in the unitary interacting system called the cosmos.

The writer first held these views in the year 1896. The first published intimation of these conclusions appeared in Volume I, No. 1, of the Transactions of the American Electrochemical Society, April 5, 1902, under the title "The Atom of Electrochemistry."

The amount of the deflection of light may be easily calculated without recourse to speculations concerning the fourth dimension and without the use of the theory of invariants.

Consider the system composed of an excitant particle of mass m and the sun of mass M . Since m is small compared with M the center of gravity of the system may be regarded as coincident with the sun's center. Locate the combined mass $(M+m) = M$ (since m is small) at this center of gravity. The sun's radius R will constitute the

distance of nearest approach of the particle m moving along its hyperbolic path into the sun's field of interaction.

Let,

t = transverse axis of the hyperbola.

v = average velocity of the excitant particle m . The upper limit of $v = V$ (the velocity of light) = 3.0×10^{10} cms. per sec. The lower limit for excitation is taken at 10^{10} cms. per sec. The average value of $v = 2.0 \times 10^{10}$ cms. per sec.

v_1 = transverse velocity.

v_2 = initial relative velocity of m and M .

R = distance of nearest approach of m to $M = 6.95552 \times 10^{10}$ cms.

γ = constant of interaction.

θ = the deflection.

I = interactional intensity; is a function of the inverse first power of the distance and the potential;
 $I = (27.64 \times 981) = 27,115$ dynes.

Then the following relations may be derived easily:

$$v = \frac{M}{(M+m)} v_2 = v_2; t = \frac{M}{(M+m)} R = R;$$

$$v_1 = v \theta = \frac{2\Delta v}{tv^2} = \frac{2\Delta}{tv} = \frac{2\Delta}{Rv}$$

where $\Delta = \gamma(M+m) = \gamma M$ (since m is small) = $I(R)^2$;

$I = 27,115$ dynes; $\Delta = I(R)^2 = 27,115 (6.95552 \times 10^{10})^2 = 1.3118 \times 10^{26}$;

$$v_1 = \frac{2\Delta}{Rv} = \frac{2 (1.3118 \times 10^{26})}{6.95552 \times 10^{10} (2.0 \times 10^{10})} = 1.88599 \times 10^5$$

$$\tan \theta = \frac{v_1}{v} = \frac{1.88599 \times 10^5}{2.0 \times 10^{10}} = 9.42995^{-6}; \theta = 1.95''.$$

The observed deflection θ was calculated from the data secured by the English Solar Expedition on May 29, 1919. Sir Frank Dyson states: "But the much better plates gave for the displacement at the limb 1.98"—Einstein's predicted value being 1.75." (See "The Reflection of Light by Gravitation and The Einstein Theory of Relativity," in the Scientific Monthly for January, 1920, page 81.)

APPENDIX F

INTERDEPENDENT AND INDEPENDENT MOTION. THE INTERACTION COEFFICIENTS. SOME BASIC FALLACIES OF PARTIAL RELATIVITY

142. Interdependent and Independent Motion.

The old notions of algebraic additivity of velocities still hold despite the fallacious interpretations put upon these relations by the partial relativists. The great service which the partial relativists have rendered to intellectual progress consists in their splendid and persistent insistence upon the general principle of relativity. It is regrettable, indeed, that they have grossly misinterpreted the meaning of their own results. They have failed to distinguish correctly between interdependent motion and independent motion just as they have failed to distinguish between real space and mathematical space.

Absolutely independent motion is purely theoretical but it may be described in terms of formal space and time. Independent motion is closely simulated by two bodies moving under independent locomotion intensities. The analysis of independent motion resolves itself into a pure mathematical investigation involving the space and time forms. When we deal with actual physical motion we are confronted with interdependent interaction resultants that can be described, in part, in terms of the forms of space and time but which involve activity factors which transform and modify the merely formal results of a purely mathematical analysis into cases of genuine physical activity vectorials. These physical activity vectorials may be redescribed in terms of the pure forms of space and time but the redescription must take account of the effects of the interdependent factors of interaction.

The Principle of Algebraic Additivity holds for velocities pertaining to theoretical independent motion. Thus if,

v_1 = velocity of particle 1,

v_2 = velocity of particle 2, and

v_r = relative velocity of particles 1 and 2, then

a For Motions in the Same Directions,

$$v_r = v_1 - v_2.$$

b For Motions in the Opposite Directions,

$$v_r = v_1 + v_2.$$

143. Interdependent Motion as Exemplified in the Phenomenon of Light.

For the relations and magnitudes of the involved velocities the reader is referred to Paragraph 108. We regard the velocity of light V as a constant ratio obtained by dividing the velocity of the excitant system v_n by the velocity of the concurrent system $v_{\frac{n}{k}}$.

From Paragraph 108 we have,

$$V = \text{relative velocity} = \frac{v_n}{v_{\frac{n}{k}}} = \text{velocity of light},$$

$$v_n = (V-1); \text{ and } v_{\frac{n}{k}} = \frac{(V-1)}{V}.$$

According to the Principle of Algebraic Additivity,

V (the relative velocity) should equal $(v_n + v_{\frac{n}{k}})$.

When we substitute the known values of v_n and $v_{\frac{n}{k}}$, however, we find;

$$(v_n + v_{\frac{n}{k}}) = (V-1) + \frac{(V-1)}{V} = \frac{(V^2-1)}{V}.$$

Be it noted that, $\frac{(V^2-1)}{V}$ is less than V . This proves conclusively that a direct application of the Principle of Algebraic Additivity apparently fails in the case of Interdependent Motion. This failure is due to the introduction of genuine activity factors which produce a new configuration in the original theoretical system. Vectorial resultants of interaction have been produced and it is futile to expect them to have the same magnitudes as the factors in the purely theoretical system. Therefore we cannot expect these transformed factors of interaction to conform with the Principle of Algebraic Additivity unless we allow for the magnitude

of the transformation. Be it noted, however, that the Principle of Algebraic Additivity is applicable to the actual, true magnitudes of the vectorial resultants. The apparent failure of this Principle is due therefore to a misinterpretation of physical facts and a consequent misapplication of the Principle.

144. Independent Motion. The Additivity Principle and the Velocity of Light.

We have seen in the preceding paragraph that it is incorrect to apply the Principle of Algebraic Additivity to the interaction factors involved in the phenomenon of light unless we make due allowance for a genuine physical transformation due to interaction. We shall now investigate the requirements of the Additivity Principle in the case of the phenomenon of light.

Let,

v_e = the velocity of the excitant system operating under the Principle of Additivity,

v_c = the velocity of the concurrent system actuating under this same Principle,

$$V = \text{relative velocity} = \frac{v_e}{v_c} = \text{velocity of light.}$$

In order that the relations may conform with the requirements of the Principle of Additivity we must have,

$$v_e = \frac{V^2}{(V+1)} \quad \text{and} \quad v_c = \frac{V}{(V+1)}.$$

The Principle of Additivity for motions in opposite directions as in the present case requires that,

$$V = v_e + v_c.$$

Substituting the previous values of v_e and v_c in the above relations we obtain,

$$V = v_e + v_c = \frac{V^2}{(V+1)} + \frac{V}{(V+1)} = \frac{V(V+1)}{(V+1)} = V.$$

Moreover, these values of v_e and v_c satisfy the requirement that,

$$\frac{v_e}{v_c} = V = \frac{\frac{V^2}{(V+1)}}{\frac{V}{(V+1)}} = V.$$

We cannot expect that these values of v_e and v_c shall be equal respectively to the values of v_n and $v_{\frac{1}{n}}$ given in Paragraph 143 because they do not refer to the same magnitudes. The values v_e and v_c refer to simple independent theoretical motion. The values v_n and $v_{\frac{1}{n}}$ refer to vectorial interaction resultants due to the simultaneous interaction of transverse and longitudinal activity factors. Therefore there is no real discrepancy in the respective values because they do not refer to the same factors.

Consequently it is a gross fallacy to attempt to place the blame for this apparent discrepancy upon a fictitious four or n -dimensional manifold. The mathematical legerdemain of the four-dimensional conjurors is interesting and exciting but it is a colossal fallacy to try to force real physical phenomena into the phantasmagoria of a non-existent, unreal hypothetical space.

145. The Interaction Coefficient in the Case of Light.

The relations between interdependent and independent motion may be expressed as coefficients to which we give the name "Interaction Coefficients." The Interaction Coefficient I_L for Light may be derived from the expressions given in Paragraphs 143 and 144 as follows:

$$I_L = \frac{v_n + v_{\frac{1}{n}}}{v_e + v_c} = \frac{\frac{V^2 - 1}{V}}{\frac{V}{V}} = \frac{(V^2 - 1)}{V^2} = \left(1 - \frac{1}{V^2}\right).$$

$$I_L = \frac{v_n}{v_e} = \frac{\frac{(V-1)}{V^2}}{\frac{(V+1)}{V}} = \frac{(V-1)}{V^2} = \left(1 - \frac{1}{V^2}\right).$$

$$I_L = \frac{v_{\frac{1}{n}}}{v_c} = \frac{\frac{V}{V}}{\frac{(V+1)}{V}} = \frac{(V^2 - 1)}{V^2} = \left(1 - \frac{1}{V^2}\right).$$

$$\sqrt{I_L} = \sqrt{1 - \frac{1}{V^2}}.$$

$$\frac{v_n}{v_{\frac{1}{n}}} \times \frac{v_c}{v_e} = 1.$$

In this form we recognize our Interaction Coefficient as the Fundamental Scalar of the Einstein Relativity for the case of a unit velocity and the velocity V .

The Genital Number n and the Interaction Coefficient I_L are related as follows:

$$I_L = \frac{(V^2 - 1)}{V^2} ; n = V, \text{ therefore}$$

$$n I_L = V \frac{(V^2 - 1)}{V^2} = \frac{(V^2 - 1)}{V} = (v_n + v_{\frac{n}{2}}) \text{ and}$$

$$I_L = \frac{(v_n + v_{\frac{n}{2}})}{n}.$$

For ordinary interacting and interdependent systems the involved velocities will be small in comparison with the velocity of light. The preceding discussion refers to the maximum condition which pertains to the velocity of light. It follows that the genital numbers in the case of the Interaction Coefficient I_L for light are V and 1 ; that is, in the secondary or logarithmic function we have included the Change Point (See Table I, Appendix-B).

In the case of the General Interaction Coefficient I_G the genital numbers of the system may be in general, designated as n and a . In that case I_G becomes identical with I_L when n reaches its maximum value V and a reaches its minimum value, that is, unity. The unit of measurement employed may readily be so chosen that $a = 1$ in the limiting case.

For the general case with the Interaction Coefficient $= I_G$ we see that:

$$n < V, n > a, \text{ and } a > 1.$$

In the limiting case when $I_G = I_L$, we have:

$$n = V \text{ and, } a = 1.$$

146. General Case of Interdependent Motion.

The genital numbers n and a are related to the velocities v_n and $v_{\frac{n}{2}}$ by the following expressions:

$$v_n = (n-a); v_{\frac{n}{2}} = \left(\frac{1}{a} - \frac{1}{n} \right) = \frac{(n-a)}{an}$$

$$\frac{v_n}{v_{\frac{n}{2}}} = \frac{(n-a)}{\frac{(n-a)}{an}} = an.$$

$$(v_n + v_{\frac{n}{2}}) = (n-a) + \frac{(n-a)}{an} = \frac{(n-a)(an+1)}{an}.$$

These relations follow as consequents from the Fundamental Relations of the Space-Time Potential. See Paragraphs 135 and 143.

147. General Case of Independent Motion.

It is clear from an inspection of the above in conjunction with Paragraph 144 that for the genital numbers n and a , the velocities v_e and v_c are given by the following expressions:

$$v_e = \frac{n^2}{(n+a)} ; \quad v_c = \frac{n}{a(n+a)} .$$

$$\frac{v_e}{v_c} = \frac{\frac{n^2}{(n+a)}}{\frac{n}{a(n+a)}} = an .$$

$$(v_e + v_c) = \frac{n^2}{(n+a)} + \frac{n}{a(n+a)} = \frac{n(an+1)}{a(n+a)}$$

148. General Interaction Coefficient.

$$I_g = \frac{(v_\pi + v_\frac{1}{n})}{(v_e + v_c)} = \frac{\frac{(n-a)(an+1)}{n(an+1)}}{\frac{an}{a(n+a)}} = \frac{(n^2-a^2)}{n^2} = \left(1 - \frac{a^2}{n^2}\right) .$$

$$I_g = \frac{v_\pi}{v_e} = \frac{\frac{(n-a)}{n^2}}{\frac{(n+a)}{n}} = \frac{(n^2-a^2)}{n^2} = \left(1 - \frac{a^2}{n^2}\right) .$$

$$I_g = \frac{v_\frac{1}{n}}{v_c} = \frac{\frac{an}{n}}{\frac{n}{a(n+a)}} = \frac{(n^2-a^2)}{n^2} = \left(1 - \frac{a^2}{n^2}\right) .$$

$$\sqrt{I_g} = \sqrt{1 - \frac{a^2}{n^2}} . \quad \frac{v_\pi}{v_\frac{1}{n}} \times \frac{v_c}{v_e} = 1 .$$

Consider the right triangle ABC in which the hypotenuse $AB = v_e$, $BC = v_\pi$, and included angle at $B = \theta$, then;

$$\frac{v_\pi}{v_e} = \cos \theta = I_g = \left(1 - \frac{a^2}{n^2}\right) .$$

Similarly for the right triangle DEF in which the hypotenuse $DE = v_e$, $EF = v_t$, and included angle at $E = \theta$ then;

$$\frac{v_t}{v_e} = \cos \theta = I_g = \left(1 - \frac{a^2}{n^2} \right).$$

Now consider the right triangle GHI in which the hypotenuse $GH = n$, $HI = \sqrt{(n^2-a^2)}$, $IG = a$, and the angle H included between GH and $HI = \theta$, then;

$$\frac{\sqrt{(n^2-a^2)}}{n} = \sqrt{\frac{(n^2-a^2)}{n^2}} = \cos \theta = \sqrt{I_g} = \sqrt{\left(1 - \frac{a^2}{n^2} \right)}.$$

This is the Fundamental Scalar Relation of the Einstein Relativity. In Professor Richard C. Tolman's work entitled, "The Theory of the Relativity of Motion" (1917), this Fundamental Einstein Scalar occurs on nearly every page. Tolman's excellent work is, in the main, an exposition of the Einstein and Minkowski theories of relativity.

The Minkowski theory is a case of four-dimensional vector analysis. The whole theory of relativity is therefore built upon and around this Fundamental Scalar Relation. The relativists derive this relation from the well known Pythagorean Theorem. They derive their basic relation from the purely geometrical relations which pertain to a right triangle. These purely geometrical relations are then imposed upon physical phenomena. The results are often misinterpreted because of their confused and erroneous notions concerning space and time which have led them into the quagmires of an unreal four-dimensional space. It is unfortunate that the relativists are not philosophers now that they have been forced into this field which science has vainly attempted to belittle by inuendo and ridicule.

The writer has derived this Fundamental Scalar directly from those basic relations of interaction which constitute the norms of his Theory of Interdependence. The author develops this important Scalar directly from the fundamental laws of action whereas the relativists develop it from a purely geometrical relation whose connection with action is thereafter sought. The method used by the relativists is replete with possibilities of misinterpreting the significance and genuineness of the hoped for connections between this

purely geometrical relation and actual physical action. The author has shown in the above the real significance of this scalar as an Interaction Coefficient.

The following subsidiary relations may readily be deduced from the foregoing:

$$\frac{n}{v_e} = \frac{(n+a)}{n}; \quad \frac{n}{v_e} = a(n+a); \quad \left(\frac{n}{v_e}\right) \div \left(\frac{n}{v_e}\right) = \frac{v_e}{v_e} = an.$$

$$\frac{\sqrt{(n^2-a^2)}}{v_n} = \sqrt{\frac{(n+a)}{(n-a)}}, \quad \sqrt{\frac{(n^2-a^2)}{v_n}} = \sqrt{\frac{(an)^2 (n+a)}{(n-a)}}$$

$$\frac{\sqrt{(n^2-a^2)}}{v_n} \div \frac{\sqrt{(n^2-a^2)}}{v_n} = \frac{v_n}{v_n} = an.$$

149. The Basic Fallacy of Relativity.

Tolman, in the work cited above (page 30), makes the following statement: "We thus find that two observers, *A* and *B*, who are in relative motion will not in general agree in their measurements of the time interval necessary for a given event to take place." He states further that time intervals made with a moving clock must be multiplied by the "Einstein Scalar" in order to agree with measurements made with a stationary system of clocks.

A complete web of confusions has grown about this primary and basic confusion of relativity. The Tolman reference deals with the geometrical relations which pertain to the sides of a right triangle as stated by the Pythagorean Theorem.

The whole matter hinges upon our interpretation of the geometrical relations which hold for the right triangle *ABC*, whose hypotenuse is *AB*, in conjunction with the velocity of light. The triangle *ABC*, according to the relativists, contains the relativity norms for a moving system when compared with the single normal line *BC*. In this moving system *ABC* the base of the triangle, that is *AC* indicates the direction of the motion of the moving system *ABC*. The relativists argue that for a stationary observer the path of a light ray reflected from a mirror parallel to *AC* in the moving system *ABC* would be given by the hypotenuse *AB* instead of by the normal *BC* to the mirror. There arises therefore, they contend, a genuine relativity of time which must

be taken account of whenever a stationary observer attempts to make time measurements of a moving system. From the Pythagorean Theorem the relativists conclude that:

$$\frac{(BC)^2}{(AB)^2} = 1 - \frac{(AC)^2}{(AB)^2}, \text{ and } \frac{BC}{AB} = \sqrt{1 - \frac{(AC)^2}{(AB)^2}}.$$

The conclusion is, according to the relativists, that it apparently takes a longer time for the same experiment in the moving system than in the stationary system when both times are measured by the stationary observer. If the stationary observer finds that the experiment in the moving system is performed in 1 second then the same experiment performed in his stationary system will only require that portion of a second which is expressed by the Einstein Scalar, that is,

$$\sqrt{1 - \frac{(AC)^2}{(AB)^2}} \text{ of a second.}$$

For this reason we must turn the whole world topsy-turvy; clocks must be properly set in moving systems, and space must be suitably "warped" in order to allow for these relativistic distortions. A further relief from this cosmic pandemonium may be had through the use of the relativistic panacea known as the fourth-dimension which is capable of warping and distorting reality to a degree satisfactory to the most exacting mathematician.

The relativists have placed a most curious misinterpretation upon the alleged relations between stationary and moving systems. We find Hermann Minkowski attempting a synthesis of space and time into a basic unitary world tetrad masquerading as a four-dimensional reality.

Let us inquire into the real significance of the results of the two experiments cited above. We at once admit that, with the velocity of light constant, the times required to traverse two paths of unequal length will be unequal. A greater time period will be required for the longer path. In this there is nothing remarkable. In fact it is nothing other than would be dictated by common sense which is and always has been a rare intellectual jewel. If the path of a ray of light be along the hypotenuse AB of a right

triangle then the time required to traverse this path will be longer than the time required to make the traverse over the normal line BC of the same right triangle because the hypotenuse AB is longer than the altitude BC of the same right triangle. This is true irrespective of the method employed in causing a ray of light to travel over these two paths. It is equally true for both the stationary and the moving system. Moreover the stationary observer can arrange, by a suitable disposition of the source of light, to exactly reproduce both experiments. Since light is a material system it is evident that it will be subject to the resultant effects of the interacting intensities. Therefore if the velocity of the moving system is commensurate with the length AC of the base of the triangle we must expect the resultant path of the ray of light to be modified accordingly. In other words, the path of the ray will be AB and not BC . The resulting path AB is therefore due to the simultaneous action of two vectorial intensities commensurate with the velocity of light and the velocity of translation of the moving system. The stationary observer can arrange, by a suitable disposition of the source of light in relation to a proper location of his point of observation, to reproduce the magnitude involved in the moving system. There will be no difference in the results produced. The only difference will be in the method of producing these results. Therefore he may derive the same inferences from the stationary system, by a new distribution of the elements of the experiment, as may be derived from his observation of the moving system. Moreover, it is futile for him to attempt to measure the time of traverse of the normal ray BC in the moving system, because the fact of motion precludes all possibility of making such measurement. Furthermore, unless light was an instantaneous phenomenon, requiring no time for its propagation, an observer located upon the moving system would find it impossible to produce a normally reflected ray from a light source regarded as a fixed point.

It is therefore evident that the stationary observer has not and cannot observe a normally reflected ray (BC) in a moving system ABC . What he can observe is the resultant path and its time period. This resultant path is along

the hypotenuse AB and since this is longer than the normal BC the time period of the former will be longer than the time period of the latter provided that the velocity of light is constant which is here assumed. By knowing the velocity of the moving system he can duplicate the involved vectorial magnitudes upon his stationary system. Therefore he need not concern himself at all with the complicated readjustment and setting of clocks in order to derive correctly all the inferences which can be derived from both experiments. In fact he did not measure the time for the normal path BC in the moving system but he measured the time element involved in a totally different path, that is, the hypotenuse AB of the moving system ABC . This time element he can more easily measure on his own stationary system by a proper readjustment of his experiment in a manner allowing for the velocity of the moving system.

The relativists have therefore rediscovered the astounding facts that, 1st, it takes light a longer time to traverse a longer path than it does to traverse a shorter path; and 2nd, they have also found that the old Pythagorean Theorem is a means of finding the relative lengths of the sides of a right triangle. Because of these astounding discoveries we are requested to accept, without protest, a new relativistic science built upon the quicksands of non-Euclidean geometry. Be it noted that they used Euclidean geometry in deriving their basic relation.

Utter confusion reigns amongst the relativists in regard to their notions of the significance of space and time. For them space and time arise, as it were, from some supermundane single essence abiding in the fourth-dimension. This single essence is, however, a tetrad capable of a four-way subdivision into coördinates conforming with the appetite of their four-dimensional Frankenstein. The relativists have, however, rendered mankind a great service in bringing forcibly before the world the general notion of relativity despite the fact that they have so grossly misinterpreted the real significance of their theory.

In his Theory of Interdependence the writer has shown that space and time are two distinct forms of apprehension, just as distinct as two separate particles of matter. Nevertheless, they are no more distinct than two particles of

matter because all particles of matter are interdependent in their physical manifestation. Space and time, although not identities possess interdependent significance in the interpretation of all the manifold types of activity.

We have shown in the above that the Fundamental Scalar of Relativity has its real origin and root in interaction from which it can be derived directly without the subterfuge of a mere geometrical relation. We have further shown that the vectors of interdependent motion may be related to the vectors of independent motion by vectorial components indicating transverse and longitudinal interaction intensities, describable geometrically by means of a right triangle which involves the author's Interaction Coefficient which is identical in its algebraic value with the Scalar of Relativity. Its real significance, however, appears in the writer's Theory of Interdependence. The relativists have failed utterly in their attempt to relate this Scalar to genuine activity.

150. Further Criticism of the Theory of Relativity.

Einstein first outlined the preliminary postulates of relativity in a paper which appeared in *Annalen der Physik*, in 1905. In this paper he considered the meaning of events occurring in different locations. We have it on the authority of his disciple, Professor A. S. Eddington, that Einstein's theory of gravitation, which follows as a consequent of his theory of space and time, was formulated sometime during the year 1915 (see Professor Eddington's article entitled "Einstein's Theory of Space and Time" in *The Contemporary Review* of December, 1919, page 640).

Sir Oliver Lodge pertinently criticises the Theory of Relativity in a paper entitled "The New Theory of Gravity" which appeared in the December issue of the *Nineteenth Century and After* (see pages 1195, 1196, 1199, and 1200). We quote the following from this paper:

"The theory—further developed by Minkowski in 1908, and adopted or modified by de Sitter, Silberstein, Eddington, and others later—lays its hands not only on ether and matter, on light and gravitation, but attacks the fundamental conceptions of Space and Time also. It evolves a generalized theory of gravity to which the Newtonian theory

is a close approximation. It attributes inertia to energy (not for the first time). It gives a theory of Space of which Euclidean space may be regarded as a special case. It involves a theory of Time which may be described as requiring four co-ordinates instead of three, to fix a position, and virtually making Time an aspect of a fourth dimension of Space. The timing of events on this theory becomes extremely complicated; it is barely possible to say even when two events are simultaneous, or to offer a criterion as to what is meant by simultaneity. Gravitation becomes a property of Space—of four-dimensional Time-Space—it therefore affects everything that occurs in space. There are ten possible coefficients instead of the common quality g , the intensity of gravity. A ray of light is not straight; the path of "least action" is affected by a gravitational field, which acts like a change in optical density and so causes a sort of refraction. Also the frequency of light-vibrations is reduced by the neighborhood of a massive body. The first law of motion, even, requires re-wording, since gravity is not a force but a property of 'crumpled' Space. The theory of relativity is a limitation, and at the same time a complication, of human knowledge."

Continuing on pages 1199, and 1200, Sir Oliver Lodge states, "But the 'warp' idea gives us a weird kind of infinity that simulates some of the properties of finiteness; Space could never be transcended, we should never arrive at a boundary wherever we start and however far we travel, and yet our environment would not be exactly what we have tried to conceive as infinite."

"The present writer," Sir Oliver Lodge says, "holds it dangerous to base such far-reaching consequences, even if anything like them can legitimately be drawn—which is doubtful—on a predicted effect which may after all be accounted for and expressed in simpler fashion. Our admiration for the brilliant way in which the fact was arrived at must not make us too enthusiastically ready to assimilate the whole complicated theory out of which it arose. So far as the present writer understands the theories of Einstein and Minkowski, he does not feel compelled to admit an essential warp or twist in Space."

This splendid criticism of the Theory of Relativity is in

complete harmony with the author's views expressed in the above. The author severely criticised the vaporous speculations of the non-Euclidean geometers in his paper "The Atom of Electrochemistry" which appeared in 1902. Now the relativists are attempting the erection of a new scientific structure upon the quagmires of non-Euclidean speculations concerning unreality.

The writer again wishes to record his vigorous protest against this "undignified nonsense" and he herewith reiterates his plea for a return to sanity and common sense.

151. A Brief Criticism of "Einstein's Theory of Space and Time."

Professor Eddington, in his article "Einstein's Theory of Space and Time," referred to in the preceding paragraph, states the following:

"In Einstein's view, since the space (b) is not revealed by physical measurements, there is no conceivable reason for believing in its existence; and in any case it does not concern us. Hence for him space is always and solely *measured space*. We cannot predict *a priori* what will happen to measuring—appliances in a strong field of gravitation, hence we cannot predict what kind of space will be there. It turns out that it is probably non-Euclidean, or, as it is popularly expressed, warped. But all the metaphysical implication disappears when we remember that this is merely a statement about the unusual behavior of measuring—appliances in unusual circumstances."

"The reader may perhaps think that it is a bathos that all the talk of the warping of space should come to nothing more than this; but he must remember that the space that is warped is actually the space of perception. The judgments of his senses are physical measures, though crude; and the applicances of the laboratory merely assist and refine these judgments without altering their character. We are inclined to overlook the channel of sense-measures by which external nature is presented to the mind, and to think that in some way the mind is directly acquainted with things outside us. So far from this being true, two of the most essential features in our mental picture of the external world—viz., space and time, are not actually in the external

world, but are introduced into the picture in the course of transmission through sense-channels to our brains."

"In every observation the observer has a share as important as that of the thing which is observed. With the observer I include any measuring-apparatus he may use to improve the judgments of his sense. Einstein's achievement is a separation of the shares of the observer and of external nature far more complete than hitherto, and opposed to the separation which through long generations we have instinctively adopted. He assigns space and time solely to the observer; in nature there is left something which for want of a better name we may call space-time. In a sense it is a combination of space and time, but it has lost the more familiar qualities of both. It arouses curiosity because it has *four dimensions*."

"The observer himself is in nature and he is passing through this four-dimensional 'something.' Let us see what he makes of it. He is sitting in his armchair making no conscious effort to change position; nevertheless, he perceives that he is not stationary in the great world—he is progressing along time. He makes a conscious effort and walks about the room; now he is progressing in space. Thus he splits up this four-dimensional thing; that direction in which he progresses without conscious effort is *time*, other directions are *space*."

"Relegating space and time to their proper source—the observer—Einstein bids us contemplate the residuum of what we observe. This residuum is the true world. It is shapeless, because we have abstracted space; yet it is metrical and has quantitative properties which can be expressed in mathematical terms. Clearly we cannot describe this true world in terms of familiar things, because the whole point of Einstein's theory is that we must abstract the ideas which we ourselves have added in order to form familiar things. Further, the laws of nature must relate to this four-dimensional residuum, and the space and time we ourselves introduce cannot be relevant. This led Einstein to the conclusion that Newton's law of gravitation, which refers to one particular separation of space and time, cannot be the exact law; and he proposed a new law applicable to a

four-dimensional world, which has now been strikingly justified by observation."

The above excerpts from Professor Eddington's article constitute an able and concise summary of the pseudo-metaphysical position of Einstein. We shall now critically consider the various contentions set forth in the preceding summary of Einstein's position.

We are told that since space is not revealed by physical measurements, there is no conceivable reason for believing in its existence. Is that interaction phase known to science as energy revealed by physical measurement? It is revealed no more and no less than space is by physical measurement. As an independent entity moving about the physical universe it is not revealed by any physical observation. What we observe are changes and transformations in material systems. We have never been able and never will be able to isolate energy as an independent existence. Nevertheless the term energy is a scientific admission that a genuine activity principle exists which accounts for the actuality of physical phenomena. No scientist can sanely deny the existence of this actuating principle upon the meagre grounds that he has not been able to isolate it by means of measuring-appliances. If the relativists elevate energy to a position of independence what then becomes of their alleged theory of relativity? It no more follows that because science has not been able to isolate the forms of apprehension, space and time, therefore both are non-existent. Their actuality is revealed through interaction of subject and object. The activity principle is also revealed to the subject by observations of the changes in the objective world.

We are also informed that it is impossible to predict *a priori* what will happen to measuring-appliances in a strong field of gravitation, hence we cannot predict what kind of space will be there. It turns out, we are told, that it is probably non-Euclidean, or, as it is popularly expressed, *warped*. If something happens to the measuring-appliances, if they are warped or deformed, we naturally inquire into the cause of this change. Einstein and Eddington, judging from Eddington's statements quoted above, rush to the conclusion that space is non-Euclidean or warped. Do they mean to tell us that space is an activity principle capa-

ble of warping the measuring-appliances? Possibly time did the warping.

Why refer to the "strong field of gravitation" at all if space or time were at the bottom of the warping phenomenon? Perhaps the strong field of gravitation first warped space which, in turn, was then able to warp the measuring-appliances. Of course it may be that the non-Euclidean warped space created the strong gravitational field which then affected the instruments. The final possibility is that the measuring-appliances themselves caused a general cosmic disturbance which retaliated by inflicting a warped condition on the cause of the disturbance.

From these possibilities the relativists arbitrarily select one possibility, that is, warped space, because this fits in with their mathematical speculations. Instead of forcing mathematics to conform with and truly represent reality, unreality must exist because it conforms with mathematical speculation. Non-Euclidean space is merely a product of mathematical imagination. It has no genuine reality other than conceptual. Nevertheless the relativists insist that the physical world must conform to this distorted and warped creature of their imagination. Mathematics is an *a priori* science grounded in depths of logical conscious life. Euclidean geometry conforms with the requirements of this logical mental life. It also conforms with the requirements of the external world which is three-dimensional. This is true because there is genuine interaction between the conscious and the unconscious world which are interdependent. Space and time therefore are not only of the subject but they are rooted in the depths of reality and because there is interaction and interdependence in the unitary cosmos therefore the mental world of Euclidean or three-dimensional properties agrees with the physical and external world. The non-Euclidean or four-dimensional world is an imaginary world based upon assumptions which have no genuine counterpart in the real physical world. The mills of mathematical logic grind with unerring truth and precision but the machinery of mathematics neither creates nor guarantees that its resulting products represent reality truly. The assumptions that are introduced into the infallible mathematical machine must be absolutely truthful.

representations of reality if the resulting products are to be labeled true and real.

The attempt of the relativists to merge space and time into a "root entity" which they name "space-time" and which is supposed to be a four-dimensional reality fails completely because of the insuperable difference between extension and duration. The distinction between space and time exists in the very foundations of the cosmos. If this distinction did not exist in the objective world it could never become known to the conscious subjective world for the reason that space and time are not mere concepts but they are genuine elements of reality. Therefore the observer does not "split up this four-dimensional thing" as Einstein and Eddington maintain. Moreover, neither space nor time is a thing and consequently any alleged amalgamation of the two cannot be termed a thing. Furthermore we are requested to contemplate the world residuum after we have subtracted the contributions of the observer. We are told that the remainder is the true world and that it is *shapeless*. Einstein thus presents us with a modern revision of the thing-in-itself of Kant with the profound philosophical insight of Kant totally absent from his four-dimensional intellectual product. We have pointed out the fallacies in the Kantian thing-in-itself in preceding paragraphs. The same criticisms hold, for this modern unphilosophical perversion. Eddington is careful to warn us that "all the metaphysical implication disappears when we remember that this is merely a statement about the unusual behavior of measuring-appliances in unusual circumstances." Why then, we ask, bring into the argument this pseudo-metaphysical four-dimensional space creature which is assumed capable of producing "warped" acts? If an iron rod expands under the influence of heat why attribute this change to the activity of a "warped space" which is neither an action agent nor a thing? Why not admit that common sense is correct in assigning the cause of this change in length of the iron rod to the presence of a real activity principle? Similarly we demand that if measuring-appliances undergo a change in "a strong field of gravitation" then the cause of this change is to be found in the activity intensities involved in the gravitational field and not in a fictitious warped

space which is neither action agent nor thing. The result of interaction may be in part described in terms of space (of three dimensions) and time but space and time are not the causes of any physical change whatsoever.

The inadvertent invasion of the realm of philosophy and metaphysics by the relativists constitutes a monumental indication of the necessity of a complete revision of the relative values of the various branches of knowledge. One may say that in a day an intellectual revolution has been accomplished. Science has been forced to incorporate philosophy into its scheme of things. Metaphysics has become an integral part of physics. Although these first philosophical attempts of the relativists resemble the first efforts of a child to walk, nevertheless they deserve commendation because they indicate emancipation from the scientific bias of the past. From now on philosophy and metaphysics must be regarded as the foundation upon which the future edifice of science must rest. No serious student of science can now afford to ignore philosophy and metaphysics. Upon this foundation the new science will become a crystal through which mankind may see God.

INDEX TO AUTHORS

N. B.—The figures refer to the numbered paragraphs

- Ampere, 39
Armstrong, H. E., 112
Avogadro, 41
Beltrami, 110
Berkely, 64
Bernoulli, Daniel, 18, 44
Bessel, 126
Bohr, 139
Bolyai, 110
Boscovich, 18, 22, 39, 44, 57, 80
Bruno, 39
Campbell, N. R., 54
Cayley, 110
Coulomb, 56
Dalton, 40
Delboeuf, 110
Democritus, 39
Descartes, 44
Eddington, 150, 151
Einstein, Albert, 109, 138,
 Table V, 150, 151
Engel, 110
Euclid, 110
Euler, 49
Faraday, 20, 39
Fechner, 39
Fitzgerald, G. F., 112
Gauss, 110
Grassmann, 110
Halsted, 110
Heaviside, 18
Hegel, 39, 67
Helmholtz, 49, 82, 110
Heracleitus, 39, 67
Hertz, 46
Kant, 39, 66, 67
Kaufmann, 18, 41, 58, 79, 108,
 132, 138
Kelvin, 49, 82
Kepler, 95, 96, 99, 126
Klein, 110
Laplace, 39
Leibnitz, 39
Leucippus, 39
Lie, Sophus, 110
Lobatchevsky, 110
Lodge, Sir Oliver, 150
Lorentz, 76, 108, 138, Table V
McDougall, 55
Mach, 110
Maxwell, Clerk, 46, 47
Mellor, J. W., 112
Michelson, A. A., 108
Millikan, R. A., 107, 132, 139
Minkowski, 148, 150
Mosotti, 53
Nagaoka, 109
Newcomb, 110
Newton, 7 (*Synopsis*), 94, 96,
 101
Parmenides, 39
Pearson, Karl, 50
Poincaré, 108, 110, 111
Poisson, 53
Riemann, 110
Russell, 110
Rutherford, Sir E., 18, 109
Schopenhauer, 66
Searle, 18
Spinoza, 67
Stevinus, 59
Stäckel, 110
Swedenborg, 39
Thales, 39
Thomson, Sir J. J., 12, 13, 18,
 20, 79, 107, 109, 132
Tolman, 148, 149
Varley, 79
Voltaire, 44
Wilson, H. A., 107, 132

INDEX TO SUBJECT

N. B.—The figures refer to the numbered paragraphs

- Absolute, 82
 - freedom, 124
 - reality, 18 (*Synopsis*), 122
 - truth, 124
- Acceleration, 5, 9
 - phase, 62
- Accident, 92
- Action, 61
 - phase, 62
- Action at a distance, 13, 18, 21, 44
- Activity principle, 9
- Ascending processes, 30, 112
- Atheism, 91
- Atom, 17 (*Synopsis*), 13, 40
 - divisibility of, 19
 - structure of Bohr's, 139
 - structure of Nagaoka's, 109
 - structure of Rutherford's, 109
 - structure of Space-Time Potential, 109, 139
 - structure of Thomson's, 20, 109
- Atomic masses, 132, Table IV
- Atomic mass moduli, 132, Table III
- Avogadro's constant, 140, Table VI
- Beta rays, 41, 79
- Cartesian development of Keplerian Laws, 96
- Categories of reality, 122
- Causes, primary and secondary, 89
- Cell action, 112
- Central forces according to Poincaré, 111
- Chance, 123
- Change point, 104, 129
- Chaos, 8
- Charge e, 107
 - calculated by the Primary Functions of Space-Time Potential, 132
 - calculated by the Secondary Functions of Space-Time Potential, 134
- Chemically equivalent atomic masses, 132, Table II
- Closed chain of concepts, 6, 10, 22
- Concepts of science, 59
- Conceptual bridges, failure of, 16
- Concurrent system, 29, 61, 77, 82, 86
 - in conjunction with excitant system as basis of phenomena of light and electric oscillations, 108
 - materialization of, 80
- Conscious and unconscious world, 121
- Conscious centers, characteristics of, 122
- Conscious world, 120
- Constants, developed from the Space-Time Potential, 132
- Contact in space, futile, 71
- Corpuscles, negative, 20
- Cosmos, 8, 23,
- Cosmos and teleology, 23
- Cosmic theories, ancient, 39
- Daniell cell, 114
- Deism, 91
- Descending processes, 30, 112
- Deterministic characteristics of elementals, 43
- Dualism of science, 37
- Dynamic equilibrium, 104
- Ecliptic, its obliquity, 100

- Electric current, 80
 as transformed mechanical energy, 85
- Electric field, 12
- Electrochemical equivalent per unit valence, 132, Table II
- Electrolytic ionization according to the Space-Time Potential, 137
- Electron, 30
 birth of, 84
 theory according to the Space-Time Potential, 131
- Electrons, flow of, 80
- Empirical position of science, 7
- Energon, 28
 gyroscopic, 83
 three phases of, 30, 84, 112, 114
- Energosial or concurrent system, 82
- Energy, 5, 9
 of electronic repulsion, 96
 phase, 63
- English Solar Eclipse Expedition (year 1919), substantiating theories of Space-Time Potential, 141
- Entities of science, two alien, 42
- Ether, 5, 44, 46, 50, 54, 75
 an irrational convenience unknown, 34
 and materialism, 17
 assumed capable of exerting pressure on moving elementals, 76
 critical analysis of hypothesis, 52, 53
 criticism of, by N. R. Campbell, 54
 inconsistent content of hypothesis, 51
 mathematical myth, 6 (Synopsis)
 mentiferous of McDougall, 55
 real purpose of, 76
- Evolution, failure of unification, 119
- Excitant system, 29, 61, 86
- Extension, 88
- Fallacy of relativity, 149, 150, 151
- Faraday lines of force, 12
- Faraday tubes, 20, 36
- Fatalism, 123
- Field of force, its implications, 47
- Fields of interaction, 78
- Finite, 13
- Force, 5, 9, 35, 38
 center, 15, 22
 center of Boscovich, 57
 not an entity, 14
 phase and mass phase, 62
 phase and space form, 63
 phase and time form, 63
- Free choice, 123
- God, 1, 14, 21, 22
 Absolute Reality, 122
 not a machinist, 23
 physical proof of existence, 24
- Gyroscopic energons, 83
- Hyperbolic function of the Space-Time Potential, 102, 103, 128
- Hyperbolic logarithms, calculations involving, 133
- Immanence, 22, 23, 58
- Immortality, assurance of, 124
 universality of belief in, 124
- Impulse, 5
 phase, 63
- Infinite, 13, 23
- Influence I, not a force, state, or action, 70
 not a thing, 69
- Inorganic centers, characteristics of, 122
- Inorganic world, 118, 122
- Instantaneous dynamics, 93
- Interaction coefficients, 145, 148
- Interdependence, theory of, 2, 3, 4, 8, 11 (all in Synopsis), 63, 67, 75, 78
- Interdependent and independent motion, 142, 143, 144, 146, 147.
- Inverse first power variation, 97
- Ionization hypothesis, criticism of, 112
- Ions in solution, 30

- Interaction, according to Boscovich, 57
 fields of, 78
 hypothesis of, 67
 in a unitary system, 63
 of interdependent centers, 75
 Kaufmann effect, according to the Space-Time Potential, 138
 Keplerian Laws, as developed by the Cartesians, 96
 as developed by Newton, 95
 as developed by the Space-Time Potential, 99, 126
 Kinetic matter, 62
 Kinetic reaction, 5
 Kinetic reaction phase, 62
 Kosmometer, 108
 Law of identity, 67
 Life entity, A unity, 119
 Light, case of interaction between excitant and concurrent systems, 15 (Synopsis), 28
 velocity of, is the limiting constant of relativity, 29, 108
 Lines of force, 12
 Logarithmic function of the Space-Time Potential, 104, 134
 Lorentz-Einstein Mass-Velocity Relation, 138, Table V
 Macrocosm, 31, 104, 136
 Macrocosmic Relations, 105
 Mass, 5, 9
 and the ether, 20
 electromagnetic, 79
 not constant, 29
 phase, measurement of, 62
 variation with velocity according to Lorentz-Einstein, 108
 Mass-acceleration center, 80
 Mass-acceleration kern, 104
 variation with velocity according to Space-Time Potential, 108
 Materialism, 91
 fallacious, 10, 11
 horror for vacuum, 22
 house of, 21
 Materialistic science, concepts invalid, 3
 Mathematical space, distinguished from real space, 110
 Mathematics, a critique of, 33
 Matter, 5, 38, 61
 as distinct from ether, 48
 as ether in motion, 49
 can it act where it is not?, 74
 electrical, 20
 Measurement, physical, 62
 Mechanical model, 1, 9
 Mechanism, pure is futile, 2
 Metageometry and space, 110
 Microcosm, 31, 104, 136
 Microcosmic relations, 105
 Millikan, on Bohr atom, 139
 Model of physical universe, 76
 Monism, 91
 Monon, 15, 27
 a unity, 72
 essential qualities of, 52
 negative and positive nature of, 81
 Motion, 61
 transmission of according to physics, 75
 Neutral ionic pairs, 112
 Newtonian, conception of universal gravitation, 7 (Synopsis)
 gravitational relation according to dynamics, 127
 law of gravitation, 96
 relation, critical analysis of, 95, 96, 98
 relation, its discrepancy with dynamics, 101
 Non-Euclidean geometry, 110
 Non-Newtonian dynamics, 93, 94
 fundamental functions of, 128
 Number, incapable of accounting for cosmos, 14 (Synopsis), 32
 Organic centers, 122
 Organic world, 119
 Pangeometry, 110
 Pantheism, 91
 Pearson, Karl, ether hypothesis of, 50
 Perpetual motion impossible, 59

- Phases of matter, 122
 Physical action, 68
 Physical concepts, relative, 60
 Physical constants, 4 and 5 of
 Synopsis
 Physico-mathematical relations
 of the Space-Time Potential, 135
 Planetary orbits, 31
 according to the Space-Time
 Potential, 99
 mathematical development
 of according to the Space-
 Time Potential, 125
 Positon, 30, 84, 85
 Potential difference, mainte-
 nance of, 58
 Potential loci, 104
 Predetermination, 123
 Primordial activity center, 27
 Primary or hyperbolic func-
 tion of the Space-Time Po-
 tential, 102, 103, 128
 Primary matter, 80, 86, 122
 Primary world, 122
 Purpose, 8, 92, 124
 Rational world order, 22
 Rationality of world, faith in, 8
 Reaction, 61
 Reason, 8
 Relative reality, 18 (Synop-
 sis), 122
 Relativity, a physical basis of,
 29
 a proof of the Existence of
 God, 59
 complete physical leads to
 negation, 4 (Synopsis)
 concepts, secondary, 63
 fallacy of, 149, 150, 151
 of Lorentz, 108
 of Poincaré, 108
 of the Space-Time Poten-
 tial, Synopsis and 108
 ordinary and partial theory
 of, 3 (Synopsis)
 physical, futile, 18 (Synop-
 sis)
 Religious intuition, 121
 Revelation, 91
 Rotary systems, 130
 Scientific renaissance, 79
 Secondary or logarithmic
 function of the Space-Time
 Potential, 104, 134
 Secondary matter, 80, 86, 122
 Selective intelligence, 17, 36,
 43
 Skepticism, absolute, 8
 Space, 6, 7, 9
 defined, 25
 not unreal, 87
 Space-Time Potential, basic
 functions of, 102
 Soul, 13 (Synopsis)
 a unity, 119
 result of a creative act, 120
 Static equilibrium, 104
 Statics and dynamics, rela-
 tivity of, 93
 Subconscious world, 117, 122
 Substance, Spinoza on, 67
 Substratum, physical, 64, 65,
 66
 Teleology, 8, 92, 124
 Theism, scientific, 91
 Thing-in-itself, 66
Theoria Philosophia Naturalis, 18, 44
 Thought, as cognition, 120
 as will, 120
 Time, 6, 7, 9
 defined, 26
 Transcendence, 58
 and immanence, 91
 of God, physical proof of, 90
 Tubes of force, 12, 13, 36
 Unitary system, 63
 Unity of things, 73
 Unknowns of science, 4
 Velocity, 5
 phase, 62
 Viton, 12 (Synopsis)
 the life ultimate, 119, 122
 Vortices of Descartes, 44
 Will, of Schopenhauer, 66
 World of subconsciousness, 117
 Worlds, the four, 116
 Work, 5
 done in a cell system, 113
 loci, 104
 loci, relations of to atomic
 structure, 139
 of decomposition, molecular,
 115
 phase, 63
 value, relatively definite for
 each point in space, 80

UCSB LIBRARY
X-79135

UC SOUTHERN REGIONAL LIBRARY FACILITY



A 000 657 739 9

